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ABSTRACT

This guide, developed for the physics 200, 300 program in Manitoba, is designed to articulate with previous science courses; provide concepts, processes, and skills which will enable students to continue in physics-related areas; and relate physics to practical applications in everyday life. It includes a program overview (with program goals and objectives for physics 200 and physics 300), information for implementing the program, and unit design charts for physics 200 and 300 core and optional topics. Physics 200 core topics include linear kinematics, vectors, motion (Newton's first and second laws of motion and circular motion), momentum and impulse, and work and energy; optional topics include solar energy, fluids and hydraulic devices, heat and energy conservation, and earth and sky motions. Physics 300 core topics include waves, static electricity, fields and forces, basic electrical circuits, basic magnetism, electromagnetic induction and alternating current; optional topics include sound, light, sunburn, earthquake prediction, alternative energy sources, science/technology/society, and special relativity. Provided for each of these topic areas is the rationale for its inclusion into the course, recommended time, and objectives with notes to the teacher. These notes include references to chapters in physics textbooks, comments about demonstrations, instructions for experiments, or other pertinent information. (JN)

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physics 200, 300

interim guide

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physics 200,300

interim guide

THIS GUIDE IS SUBJECT TO REVISION ON THE BASIS OF INFORMATION RECEIVED FROM SCHOOLS. IT IS EXPECTED THAT MODIFICATIONS WILL NOT BE IN THE DESIGN OF THE PROGRAM. RATHER, CHANGES MAY BE MADE IN AREAS CONCERNING STRATEGIES, RESOURCE MATERIALS, AND IMPLEMENTATION.

province of manitoba
department of education 1984

This guide replaces the *Physics 200, 300 Guide* published in 1974. It was prepared by the Department of Education to meet the needs of the students of Manitoba. The pilot guide was tested in Manitoba schools from 1981 to 1983 and has been revised on the basis of the feedback obtained from teachers and students. *Physics 200, 300* becomes the approved provincial guide effective September, 1985.

This course has been designed to articulate with previous sciences, provide concepts, processes, and skills which will enable students to continue in physics-related areas, and relate physics to practical applications in everyday life.

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program overview

INTRODUCTION

"Physics today has become a major science, because much of what goes on around us in the world is governed by the laws of physics. The rapid advances made by physicists since the turn of the century have helped man probe into the mysteries of nature. Today's world is the world of rockets, satellites, computers, and supersonics. It is a world where automation and miniaturization are already controlling man's future life."[1]

Modern technological developments have made the teaching of physics a fascinating and necessary experience for the teacher and the student alike.

"It is inconceivable that in the modern technological age, it could be seriously disputed that sciences should be an essential part of a broad training to be given to all children up to about the age of 16--a training that is not intended to prepare them for any particular occupation that we can devise for their entering into the adult world. Physics is the most fundamental of sciences and therefore is clearly essential. Our view does not rest upon the obvious usefulness of physics in a technological world. On the contrary, we have stressed that the claim of physics to be part of education of all children stems from the place that the subject occupies in the intellectual heritage to which we seek through education to introduce our children."[2]

"It is clear at present to everybody that it is precisely the progress of physics that determines the possibilities of development in a wide range of sciences, from cosmology to biology, and medicine. It is physics that determines to a large extent the foundations of our outlook as well as the possibilities and limitations of our practical activities. One cannot be called a specialist or, for that matter an educated person unless one is familiar with a certain range of ideas and facts in the sphere of physics."[3]

The relationship of physics to the progress of other sciences, its methods of acquiring and evaluating knowledge, and its present and potential functions in many aspects of our technological world makes physics education an important aspect of the education of all students.

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[1] R. K. Goyal, "Some Reflections on Physics Teaching in the Secondary Schools of India and America," unpublished M.N.S. thesis, Arizona State University, May 1967.

[2] "Why Teach Physics," International Education Conference on Physics in General Education, Brazil, M.I.T. Press, Mass., 1964.

[3] Proceedings of the International Conference on Physics Education, Unesco House, Paris (July 18 to August 9, 1960).

RATIONALE

"One can say: The eternally incomprehensible thing about the world is its comprehensibility."[4]

"A general education for the sciences should make it possible for people to appreciate the worthiness of the scientific enterprise and to use its achievements for attacking contemporary problems as well as designing the future we seek."[5]

An increased amount of information and debate about the effects of science and technology upon the environment and society has led to changing perceptions concerning the potential role of science in society and of science education in preparing students for the future. In addition, continuing research resulting in new perceptions of the needs and abilities of high school students has necessitated a review of the purposes, emphases, and design of science programming. As part of the review, the K-12 Science Working Party surveyed high school physics teachers and reviewed the literature related to education in physics. Information obtained by the Working Party indicated that the following factors in the design of the physics curriculum should be adjusted: 1) the number of recommended topics should be decreased in order to provide a more flexible program; 2) a review of the nature and need for articulation with post secondary institutions should be conducted in order to provide a clearer definition of how physics education in high school can prepare students for potential future vocations; 3) some emphasis upon the relationship between science, technology and society should be introduced into the program; and 4) the level of the program should be related to presently understood knowledge of the developmental levels of students.

In examining the relationship between science, technology and society, the following comments appear to be pertinent: "An assessment of the value of nuclear power . . . ultimately requires an examination of the acceptability to society of the risks and benefits of the technology, relative to other opinions."[6]

"In normal operation, the once-through nuclear fuel cycle seems to have less environmental impact than most large scale energy systems. One can compare its effects with acid rain, carbon dioxide build up, extensive use of land for gathering renewables, flooding and other effects of hydro projects, and deforestation."[7]

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[4] Albert Einstein, "Physics and Reality," in Ideas and Opinions, trans. S. Bargman (New York: Crown, 1954).

[5] Paul D. Hurd, "Scientific Enlightenment for an Age of Science," The Science Teacher (January 1970).

[6] Royal Commission on Electric Power Planning, A Race Against Time (Toronto: Queen's Printer, 1978).

"Finally there are probably only two possible ways to control technology. Either we control it with alternative technology or we attempt to abandon some of it altogether."[8]

The ability of science to generate new understandings about the nature of matter and energy and the continuing success whereby science and technology have applied this knowledge has led to a growth in the ability of humans to control their lifestyles. This very success has helped to focus our attention upon the dual nature of progress. Like two sides of a coin, the ability to modify the properties of non-renewable fossil fuels has enabled us to use these resources at an increasing rate and has led to concerns about the atmospheric effects, the possibility of using finite resources too rapidly, and the need to consider and develop alternate sources of energy. Similarly, the development of nuclear energy as an alternate energy source presents unresolved problems in regard to the disposal of waste products. All possibilities offer choices to the individual. If rational choices are to be made, both knowledge of the sciences and ability to apply this knowledge to alternatives are important. One aim of this course is to provide students with the opportunity to develop an understanding of the nature of interactions in physics and their relationship to technology and society. A related aim is to develop decision-making skills which will enable students to examine alternatives within the interactions. These skills include the ability to interpret and judge the validity of data and the importance of factors which may affect alternate choices.

Many students use their studies in physics for purposes of further study in pure and applied sciences. Some degree of uniformity in basic ideas presented to students is important for future success in studying physics at post-secondary institutions. Both basic concepts and skills which represent the nature of physics and the needs of post-secondary institutions are defined within a segment of the program described "core." In addition, portions of core can be related to objectives representing the interaction of science-technology and society. In order to provide time for both aims, the time required for core in previous physics courses was decreased.

"Various studies indicate that from 25% to 75% of high school and college students do not successfully use such components of formal reasoning as: 1) using proportions; 2) making quantitative correlations; 3) making all possible combinations; and

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[7] R. W. Morrison, "Nuclear Power in Developing Countries," in *Moral and Ethical Issues Relating to Nuclear Energy Generation*, ed. D. R. Hardy (Toronto: Canadian Nuclear Association, 1980).

[8] S. M. Najm, "Technology and its Human Implications," in *Moral and Ethical Issues Relating to Nuclear Energy Generation*, ed. D. R. Hardy (Toronto: Canadian Nuclear Association, 1980).

4) controlling variables, etc."[9]

Proportional reasoning is seen by many scientists and science educators as one of the keys to understanding and applying many of the formal concepts in physics programs. Because about 22 to 25 percent of Manitoba students elect physics, high school physics students will vary greatly in their abilities to use some abstract concepts and certain tain kinds of reasoning, such as proportional reasoning. In order to help students to develop these abilities, it is important that we continue to emphasize a laboratory approach using concrete situations, relate the concrete situations to formal concepts, and apply the principles in a wide variety of situations. In order to provide opportunities for teachers to give students both a concrete approach and a variety of opportunities for students to apply principles and consider their solutions, time has been made available by decreasing the amount of core content. In addition, a variety of materials and laboratory activities has been identified.

PSYCHOLOGICAL BASIS FOR CURRICULUM DESIGN

Any curriculum is a plan for providing sets of learning opportunities for persons to be educated. The development of that plan involves considering the major purposes and aims of education, that is, classifying goals and objectives, selecting a curriculum design, and writing a plan. All of these activities are guided by data about the learners, the society being served, and the nature of the environment in which the learners live. Knowledge from different disciplines is used for developing the plan.

The curriculum design selected has a direct bearing on the instruction provided. No single design can achieve equally effectively all the goals and cater to the needs of a varied student population in the schools. To be effective, any curriculum must show flexibility in terms of individual needs and the needs of the society.

Psychology as a discipline has made many contributions to curriculum planning and teaching. In fact, it has played a leading role in shaping schools and has profoundly influenced what happens within the classrooms. Data regarding human development have come, in large part, from psychological studies. In addition, psychology has contributed ideas to a vast array of educational topics, including such topics as motivation and self-concept. Of major interest to curriculum designers is the contribution of psychology to learning. Learning theory is concerned with meaningfully learned material. Meaningful learning, according to psychologists, requires that new material be related to relevant aspects of existing conditions, and that the resulting new material to be reconciled with established knowledge. Different individuals develop different ways of learning and organizing information, and any new curriculum design must take this fact into account by providing options. The curriculum and its implementation will be improved when it is based upon this understanding. Curriculum designers must recognize the developmental nature of learning and the importance of the old saying that "teaching must start where the learner is." Readiness, thus, becomes an important consideration in building a curriculum.

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[9] Ron Good, Robert A. Kromhout and E. K. Mellon, "Piaget's Work and Chemical Education," Journal of Chemical Education (July 1979).

GOALS OF THE PHYSICS 200, 300 PROGRAM

The science of physics rests on observation. The principles or laws of physics represent the summary of observed phenomena and their logical interrelationships. These interrelationships, in the form of concepts, when applied in the technologies, have led to advances which have significantly affected society. It is essential that young people be exposed to the principles and applications of physics during their high school careers. The objectives of the physics program are:

1. To increase students' knowledge of basic concepts in selected topics such as classical mechanics, electricity and magnetism so that he/she will be able to:
   - interpret and evaluate fundamental ideas;
   - relate scientific concepts to everyday life;
   - make informed choices about future studies or careers.

2. To enable the student to develop and apply the skills of science. These skills include:
   - science process skills;
   - interpretative and computational skills based on collected data;
   - communication skills related to the gathering and interpretation of information;
   - those psychomotor skills which are required for first-hand investigations.

3. To develop students' interest in and appreciation of scientific values and problem solving and to promote attitudes such as curiosity and open-mindedness, respect for accuracy, precision, the tentativeness of evidence and the principle of causality.

4. To promote an understanding of the relationship between physics and technology, their impact upon the individual and society in order to help students to:
   - recognize that science and technology are interdependent;
     - science is dependent upon technology for tools, techniques and the formulation of basic ideas;
     - technology is dependent upon basic science for the development of new knowledge and explanations;
   - recognize the human tendencies to reject theories and research findings that conflict with tradition or accepted practices;
     - recognize that scientific activities and results are regulated by a set of values. These values include:
       a. longing to know and understand;
       b. questioning of all things;
       c. searching for data and their meaning;
       d. demanding verification;
       e. respecting logic;

   f. considering premises;
   g. considering consequences.[11]

- recognize that, in some cases, values of science may be in conflict with values from other "ways of knowing and understanding";
- describe the difficulty of preventing unforeseen side effects from occurring as a result of efforts to control imperfectly understood natural processes;
- recognize the finiteness in the supply of most raw materials that are now in demand;
- describe the cost of human material comfort and its interdependence with the level of consumption of energy and raw materials;
- describe the interdependence of human material comfort and environmental effects;
- explain the role of science and technology in increasing human material comfort;
- examine alternative solutions to science-technological-environmental comfort;
  - understand the limits of scientific knowledge relative to solutions of present problems;
  - recognize the trade-offs, technological and economic, which are necessary to solve problems;
  - develop a concern and understanding on the part of the student about the responsibility of the public and industry to ensure that future generations will be able to enjoy the same quality of life of the present generation;
- develop decision-making skills to solve problems;
  - identify the significant elements and implications of an issue;
  - distinguish among facts, opinions, beliefs, conclusions and value judgements;
  - identify logical relationships among the elements of an issue;
  - collect, organize, evaluate and present information about an issue.

OBJECTIVES FOR PHYSICS 200

CORE UNITS

Unit 1: Linear Kinematics

1.0 Distinguish between the following terms:
   . displacement and distance (d);
   . velocity (v) and speed.

2.0 Define acceleration and analyze graphically.
   2.1 Graph "d vs. t," "v vs. t" and "a vs. t."
   2.2 Apply the equations of motion (which the teacher has "derived").

$$d = \frac{(v_1 + v_2)t}{2}$$

$$v_f = v_i + at$$

$$v_f^2 = v_i^2 + 2ad$$

$$d = v_i t + \tfrac{1}{2}at^2$$

---

[11] M. A. Nay and R. K. Crocker, "Science Teaching and the Affective Attributes of Scientists," Science Education 54 (1970):59-67.

2.3 Apply the equations of motion to freely falling bodies using "g."

Unit 2: Vectors

1.0 Apply vector addition to linear problems.

2.0 Define vector subtraction as vector addition with a negative vector and apply to problems; apply vector subtraction using the tail-to-tail method.

3.0 Use scale diagrams to solve for a vector sum or difference.

4.0 Resolve a vector into components using:
- scale diagram method
- trigonometric method

Unit 3: Dynamics of Motion--Newton's Laws of Motion

1.0 Describe different types of forces which exist in nature.

2.0 Determine, experimentally, by using a low friction device, e.g., air tables, whether zero force yields zero acceleration and determine the same way (and graphically), the relationship between force (F) and acceleration (a), e.g., F=Ma. The law of inertia can be shown.

2.1 Describe and apply Newton's first and second laws of motion.

3.0 Define the appropriate units of force (e.g., the newton).

- define weight

4.0 Define Newton's Third Law in qualitative terms by using examples.

Unit 4: Dynamics of Motion--Circular Motion

1.0 Analyze projectile motion emphasizing the independence of horizontal and vertical motion.

2.0 Describe that the force causing circular motion (centripetal force) is a centre-directed force which causes a constant centre-directed acceleration.

3.0 Apply the concept of centripetal force to practical examples.

4.0 Develop Kepler's Laws of Planetary Motion.

5.0 Develop Newton's Law of Universal Gravitation from Kepler's Law.

6.0 Apply the Law of Universal Gravitation to a variety of situations.

7.0 Use Kepler's Law of Periods. $K = R^3/T^2$, the formulae for circular motion, and $4\pi^2K=GM$ to arrive at $F=GM_1M_2/R^2$.

Unit 5: Momentum and Impulse

1.0 Describe, qualitatively, the nature of impulse and momentum.

- 1.1 Derive $F\Delta t = m\Delta v$ from Newton's Second Law.

- 1.2 Apply impulse equals changes in momentum to situations where the force is not constant, but is changing linearly, e.g., area under a linear "Ft" graph.

- 1.3 Apply the equations of momentum change and impulse (teacher derived).

2.0 Define Newton's Third Law both in qualitative and quantitative terms.

3.0 Apply the Laws of Conservation of Momentum qualitatively to linear explosions.

4.0 Qualitatively describe conservation of momentum in non-linear explosions.

5.0 Apply the law of conservation of momentum to collisions between two masses in one and two dimensions.

- 5.1 Define the centre of mass.

- 5.2 Locate the centre of mass for a two-body system.

- 5.3 Qualitatively describe the motion of the centre of mass in explosions and collisions (one-dimensional only).

Unit 6: Work and Energy

1.0 Define work and power in terms of Work = Force x Distance and Power = Work/Time and Power = Fxv.

- 1.1 Define work as the area under a force-distance graph. Interpret graphs.

2.0 Define two types of mechanical energy: kinetic energy and potential energy.

3.0 Describe the energy transfers that occur during an interaction involving both potential and kinetic energy.

4.0 Quantitatively apply the principle of mechanical energy to elastic collisions.

5.0 Quantitatively distinguish between elastic and inelastic collisions.

OPTION UNITS

Option 1: Facts and Information Analysis

1.0 Distinguish and describe the differences among:
- facts and value judgements or opinions;
- direct and indirect observations;
- observed and inferred facts;
- historical and scientific facts.

- 1.1 Describe some difficulties in obtaining or accepting observed fact on the basis of perception and stored knowledge.

1.2 Compare deductive and inductive methods.

2.0 Distinguish and describe differences among hypotheses, scientific laws and theories.

2.1 Relate the nature and limitations (uncertainties) of models to scientific theories.

2.2 Describe limitations in scientific laws.

Extension One (Statistical Facts; Science, Invention and Social Interaction)

1.0 Describe ways of presenting facts statistically and methods of presenting information in an incomplete or biased manner.

1.1 Describe precision and reliability in statistical data and the effect of choosing different bases upon percentage.

1.2 Describe the potential sources of bias in surveys and averages (median, mode, mean).

1.3 Describe how graphical data may be biased by using no or unspecified axes, changing axes and scales, changing origins, and pictographs or non-linear graphs.

1.4 Illustrate, with examples, the dangers of extrapolation.

2.0 Specify alternative definitions of risk (including a quantifiable definition), methods of determining risk (including strengths and weaknesses), the difference between risk, estimation and risk evaluation, and the concept of balancing risks against benefits.*

3.0 Describe factors that affect the development of new ideas or inventions (creative factors, serendipity, intuition).

Optional Objectives (if desired)

4.0 Relate the nature of science as a way of knowing to religion as a way of knowing.

5.0 Analyze a report using selected criteria.

Extension Two (Development of Scientific Ideas: Societal Background)

1.0 Describe the effect of the growth of technology upon ancient societies and the societal factors affecting the growth of science and technology.

1.1 Describe the versatility of Leonardo da Vinci and the reasons for the growth of knowledge during this period of time.

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* This objective would require a number of hours to develop and could be deferred to the unit on energy alternatives.

1.2 Describe how new scientific ideas may develop conflict within a society.

1.3 Specify how Newtonian ideas unified scientific thought and affected views of society.

Option II: Solar Energy

1.0 Describe solar energy relative to the electromagnetic spectrum and relate this to the major components reaching the earth's atmosphere.

2.0 Describe heat losses and transfers.

2.1 Describe, qualitatively, the absorption, reflection and transmission of solar energy in the Earth's atmosphere.

2.2 Relate variation in solar radiation to factors such as solar altitude or azimuth, direct and diffuse radiation and the tilt of the solar collector (Earth).

2.3 Use the terms conduction, convection and radiation to explain heat transfer in the atmosphere and in buildings.

2.4 Measure the relative intensity of solar radiation.

2.5 Describe the variation of the solar intensity on a daily, monthly and yearly basis.

3.0 Describe ways in which entry of solar energy into a building can be controlled.

3.1 Describe the importance of and give examples of retrofitting.

3.2 Describe important characteristics of a low-energy dwelling.

3.3 Define the greenhouse effect and thermal mass. Relate the characteristics of thermal mass to use in solar heat storage.

3.4 Relate the role of thermosiphons to passive collection of solar energy. Observe and describe the function of a convection loop.

3.5 Describe ways in which loss of solar energy can be minimized. Make recommendations about approaches to and importance of conserving energy in homes.

3.6 Describe methods of increasing passive storage capacity.

3.7 Compare the effectiveness of different colours upon solar radiation absorption.

4.0 Compare thermal heat and latent heat of fusion. Calculate solar energy, stored as heat, using $h=vc\Delta t$, v = volume in m^3, c = heat capacity in megajoules per cubic metre degree Celsius and "h" is in megajoules.

4.1 Calculate the savings of certain solar energy applications and relate to present energy costs. Estimate potential future savings.

4.2 Compare the solar heat storage characteristics of different materials. Graph the results.

4.3 Compare the advantages and disadvantages of different methods of heat storage.

5.0 Describe the characteristics and operation of active solar collectors and systems.

5.1 Discuss factors affecting the efficiency of active systems and compare active and passive systems relating to practical and economic factors and advantages or disadvantages.

5.2 Describe the characteristics and give examples of concentrating solar collectors and solar cells.

Option III: Fluids and Hydraulic Devices

1.0 Calculate specific gravity of solids, liquids and gases from the concept of density.

2.0 Describe pressure in physical mathematical terms.

2.1 Distinguish between force and pressure.

2.2 Solve problems involving the parameters of pressure, force, area, specific gravity and height.

2.3 Demonstrate that pressure is independent of configuration of the container.

2.4 Describe the nature of atmospheric pressure in qualitative and quantitative terms.

2.5 Distinguish between gauge pressure and absolute pressure.

3.0 Describe Pascal's Principle and demonstrate understanding with qualitative and quantitative illustrations.

3.1 Identify practical examples of Pascal's Principle.

3.2 Calculate force input and force output using simple hydraulic piston arrangements.

Option IV: Heat Concepts and Home Energy Conservation

1.0 Define heat as a form of energy.

1.1 List different forms of heat such as sun, friction, electrical.

2.0 Define heat units.

2.1 State the relationship between joules and calories.

2.2 Measure and define heat exchange.

2.3 Measure and define heat capacity.

2.4 Experimentally determine the specific heat of water and one or two other substances, e.g., aluminum, brass.

3.0 Describe factors affecting heat transfer.

3.1 Describe the three factors (material, thickness, temperature difference) which affects conduction.

3.2 Describe the factors affecting convection (cellular construction, geometrical control, loss of warmest material).

3.3 Describe the factors affecting radiation loss (difference between absolute temperature to fourth power).

4.0 To keep the heat in his/her home and the cold out (old homes or new).

4.1 Know the meaning and advantages of retrofitting in relation to money, comfort, energy.

4.2 Know the basics of how a home is built, e.g., foundation, structure, cellar, windows and doors, ceiling and roof.

4.3 Relate home insulation factors such as R values, vapour barrier, floors, doors, windows, ceilings to conservation of heat.

Option V: Motion: Earth and Sky

Part 1:

Motion: Heavenly Objects*

1.0 Identify major constellations on a star chart or stellar globe.

1.1 Provide the names and positions of the major planets visible at the time of this option.

1.2 Describe the regularities in the motions of the sun, moon, stars and planets.

1.3 Graph planetary motion for Mercury and Mars relative to the sun.

1.4 Plot the path of the sun, using a gnomon.

1.5 Construct a sundial, an astrolobe and a celestial globe.

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* Check with students initially in case they have studied some of the ideas at an earlier time.

Models of the Universe

2.0 Compare Greek models of the universe (e.g., Plato's and Eudoxus' models).

2.1 Defend the Greeks' geocentric model of the universe as being most useful and appropriate to their time. Relate this to the nature of scientific truth at that time.

2.2 Define retrograde motion relative to planetary motion.

2.3 Describe the successes and limitations of the Ptolemaic model of the universe.

Does the Earth Move? Copernicus

3.0 From data on the sun's position in the sky, construct the orbit of the earth.

3.1 Construct a Foucault pendulum and relate its action to a rotating earth.

3.2 Describe the strengths and weaknesses of the Copernican model of the universe.

Observations and Models: Kepler and Galileo

4.0 From data, construct the orbit of Mars or Mercury.

4.1 State and describe the development of Kepler's Law of Periods.

4.2 Apply Kepler's Law of Periods to data from other planets such as Jupiter.

4.3 Describe how evidence about the sun and moon developed by Galileo via telescope weakened the earth-centred view of the universe.

4.4 Describe how the scientific evidence of the sun-centred model conflicted with other beliefs.

PART II

Gravitation: Newton to Einstein

5.0 Describe how the force of gravity can be responsible for the laws of motion for falling bodies and heavenly bodies.

5.1 Describe and apply the concept of centrifugal force to planetary orbits.

5.2 Describe the different kinds of orbits possible based on gravitational force laws and provide examples from heavenly bodies.

5.3 Describe how application of the Law of Universal Gravitation helped to predict the presence and location of heavenly bodies.

5.4 Describe how Cavendish weighed Earth.

5.5 Compare Newtonian concepts of gravity to modern concepts of gravity and the universe. Relate this to modern views of the nature of the universe.

OBJECTIVES FOR PHYSICS 300

CORE UNITS

Unit 1: Waves

1.0 Describe waves in terms of transmission of energy.

2.0 Distinguish between longitudinal and transverse wave systems.

3.0 Physically describe waves in terms of amplitude, frequency, wave length and velocity.

4.0 Derive the relationship $V=f\lambda$.

5.0 Observe and describe the following wave properties:
  a) Rectilinear propagation
  b) Reflection
  c) Refraction
  d) Diffraction
  e) Impedence
  f) Interference

6.0 Relate interference phenomena to:
  a) Superposition of waves
  b) Standing waves

7.0 Apply wave phenomena to some aspects of sound and light such as Doppler effect and resonance.

Unit 2: Static Electricity

1.0 Define the concept of charge in terms of conservation of charge.

2.0 Differentiate between insulators (non-conductors) and conductors in terms of the mobility of electrons.

3.0 Demonstrate like-charge repulsion and unlike-charge attraction. Demonstrate charge by contact and induction.

4.0 Explain charging by contact in terms of static electrical theory.
  4.1 Explain charging by induction in terms of static electrical theory.
  4.2 Explain "grounding" as applied to charging and discharging.

Unit 3: Fields and Forces

1.0 Sketch the force field about a charged body.

2.0 Demonstrate the existence of fundamental units of charge.

3.0 Measure the force between charges.
  a) Define the quantity of charge as a coulomb. One coulomb is equal to 6.25×10^{18} elementary charges.

4.0 Describe how capacitors store an electrical charge.

  4.1 Define dielectric materials.

5.0 Describe the motion of charges between charged plates.

  5.1 Quantitatively analyze the energy changes that occur when a charged particle is accelerated between two charged, parallel plates.

5.2 Relate the potential energy of the source to the energy gained by the charge.

6.0 Define volts in terms of joules and coulombs.

7.0 Define ampere as the number of coulombs moving past a point in a conductor in one second.

8.0 Calculate the work done in moving charges.

9.0 Define power as work done per unit time in moving charges.

Unit 4: Basic Electrical Circuits

1.0 Develop Ohm's Law from data.

1.1 State that resistance is a property of the circuit element. Define the ohm.

2.0 Describe sources and characteristics of electrical energy (e.m.f.):

- produce a fairly constant difference of potential;
- have polarity (+, -);
- cause flow of current when a circuit is completed.

2.1 Infer that the amount of the current is determined by the voltage of the source and the resistance of the circuit.

2.2 Describe types of sources of e.m.f. (different types of cells, generators, photocells).

3.0 Describe the characteristics of a simple series circuit:

- uniformity of current
- individual voltage drops add to total potential difference applied to circuit.

3.1 Compute total resistance in a series circuit.

3.2 State that the sum of the resistors equals total resistance of the circuit and apply the relationship: $R_t = R + R_2 + R_3 + \ldots R_n$.

3.3 State and apply the concept that resistances in series operate as voltage dividers in direct proportion with the resistance.

3.4 Compute the total power developed in a series circuit.

3.5 Demonstrate that the sum of the power developed by the individual elements in a circuit equals total power developed by the circuit. Apply this concept.

4.0 Compute the current in the branches of a parallel circuit.

4.1 Infer that the sum of the current in the individual branches adds up to the circuit current.

4.2 Describe that a parallel branch serves as a current divider in an inverse proportion to the resistance.

4.3 Compute the voltage drops in a parallel circuit.

4.4 Demonstrate that the voltage drop across each member of a parallel group is the same.

4.5 Compute the total resistance of a parallel group.

4.6 Derive the relationship:

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots \frac{1}{R_n}$$

4.7 Infer that the combined resistance of a parallel group is less than that of the smallest resistor in the group.

4.8 Calculate the current and voltage drop for any portion of a compound circuit (series and parallel).

4.9 Compute the total power developed by a compound circuit.

4.10 Calculate the power generated by individual elements in a compound circuit and the total power developed by the individual elements.

4.11 Infer that the sum of the power developed by the individual elements equals the power developed by the total circuit:

$$P_t = P_1 + P_2 \ldots + P_n.$$

5.0 Describe the factors affecting the resistance of a uniform conductor.

5.1 Infer the relationship between resistance of a conductor and length, cross sectional area and kind of material.

6.0 Apply the principles to practical problems involving various kinds of circuits.

Unit 5: Basic Magnetism

1.0 Sketch a magnetic field around a current-carrying conductor, a permanent magnet, and a solenoid.

1.1 Demonstrate the rule for direction of a field around a current-carrying conductor.

2.0 Develop the formulae for a magnetic field around a straight wire, in the centre of a loop and in the centre of a solenoid.

2.1 Perform sample calculations to find the strength of a field:
- calculate the force on a moving charge
- derive $F = qVB_{\perp}(VIB_{\perp})$
- derive $F = B_{\perp}IL$

3.0 Measure the force of a magnetic field on a current-carrying conductor.

3.1 Employing rules, predict the direction of the force.

3.2 Calculate the force on a current-carrying conductor.

4.0 Compute the force between two straight current-carrying conductors.

4.1 Define the ampere in terms of force between two parallel current-carrying conductors.

Unit 6: Electromagnetic Induction and Alternating Current

1.0 State the causes of induced currents.

2.0 Describe and define magnetic flux as $\phi = B\ A$.

3.0 State Faraday's Laws and relate the laws to practical examples.

$$E = \frac{\Delta\phi}{\Delta t} \quad \text{and} \quad E = \frac{N\Delta\phi}{\Delta t}$$

3.1 Calculate the strength of induced e.m.f.

4.0 Define Lenz's Law and apply the law to predict direction of induced e.m.f.

5.0 Describe how current is induced in a rectangular armature in a uniform magnetic field.

6.0 Describe the AC cycle.

6.1 Describe the operation of a commutator.

7.0 For alternating currents, compute effective current and voltage.

7.1 Define effective values of amperes and volts.

7.2 Qualitatively describe the effect of impedance on Ohm's Law in AC.

8.0 Describe the operation of AC motors.

8.1 Describe, qualitatively, the production of back e.m.f. motors.

8.2 Explain, qualitatively, the motor effect of generators.

8.3 Observe the generator and motor effects on a generator.

9.0 Describe the operation of transformers in terms of:

- power input = power output
- power depends on output turns ratio

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

9.1 Describe how the flux changes in transformers cause the output.

OPTION UNITS

Option 1: Sound

1.0 Describe the relationship between sound and vibration.

2.0 Explain sound in terms of waves.

   2.1 Apply the wave formula $\lambda = v/f$.

   2.2 Distinguish among three aspects of any sound, i.e., sound, wave transmission, detectors.

   2.3 Explain how sounds are reflected from surfaces, echoes, reverberations, absorption.

   2.4 Define and differentiate between ultrasonic and infrasonic.

   2.5 Describe applications of ultrasonic and infrasonic sound.

3.0 Describe the factors affecting sound transmission.

   3.1 Compute the speed of sound in air at various temperatures.

   3.2 Compare the speed of sound in two other mediums to speed in air.

   3.3 Describe the Doppler Effect.

   3.4 Calculate the effective frequency of sound as affected in the Doppler Effect.

   3.5 Explain the creation of a sonic boom.

Section I: Noise

4.0 Describe the operation of the human ear.

5.0 Define presbycusis, i.e., hearing loss specifically attributed to aging effects or occupational noise.

   5.1 Explain the concept of threshold of pain.

   5.2 Describe intensity of sound measurement.

   5.3 Describe and provide supporting information about the relationship between hearing damage and intensity of sound.

Section II: Music

6.0 Describe the characteristics of sound waves in vibrating strings and wires.

   6.1 Explain the production of tones in a wire or string.
   - fundamental
   - second harmonic
   - third harmonic, etc.

   6.2 Use the law of strings to predict vibration frequency in a wire or string.

7.0 Explain the production of resonance as a sympathetic vibration produced by a transfer of energy.

7.1 Compute the wavelength of sound using resonating air columns.

7.2 Relate the speed of sound to resonating air columns.

8.0 Distinguish between music and noise.

9.0 Describe the use of wave theory (acoustics) in the design of rooms, concert halls, bridges, etc.

Option II: Light: Geometrical Optics and Optical Instruments

1.0 Define and draw normal, angle of incidence, angle of reflection in relation to plane mirrors.

1.1 Locate images in plane mirrors using ray diagrams.

1.2 Verify the principles of reflection (location of image, relationship between angle of incidence and reflection).

2.0 Describe the operation of concave and convex mirrors.

2.1 Define and illustrate virtual, erect, size, principal axis, principal focus, centre of curvature and spherical aberration.

2.2 Describe images and locate images:
- real or virtual
- erect or inverted
- enlarged, diminished, or same size

2.3 Illustrate image location by using ray diagrams.

2.4 Solve problems using

$1/Do + 1/Di = 1/f$ and $M = Di/Do$

3.0 Define the following terms in relation to lenses:
- concave and convex
- converging and diverging
- refraction and centre of curvature
- focal length

3.1 Describe and locate images:
- real or virtual
- erect or inverted
- enlarged, diminished, or same size

3.2 Illustrate image location using ray diagrams.

3.3 Find the focal point of a simple magnifying glass.

3.4 Solve problems using:

$1/Do + 1/Di = 1/f$ and $M = Di/Do$

4.0 Apply what he/she has learned about lenses to simple optical instruments.

4.1 Describe the use of lenses in a telescope (focal length, objective lens, eyepiece, distance between lenses, and magnification).

4.2 Describe the uses of lenses in the microscope and how such large magnification occurs. Be able to illustrate with a ray diagram.

4.3 Apply the principles of lenses and mirrors to binoculars and reflecting telescopes.

4.4 Describe the principle of operation of a simple camera.

Option III: Sunburn

1.0 Describe waves.

1.1 Recall from previous study of wavelength the relationship of v, f, and λ.

1.2 Describe the different types of waves on the electromagnetic spectrum and physical dangers of these waves.

1.3 Describe diffraction of mechanical waves and light waves.

1.4 Describe light which cannot be detected by the human eye.

1.5 Determine the wavelengths of light.

1.6 Do problems on wavelength of spectral lines.

2.0 Describe how solar radiation is filtered out by the earth's atmosphere depending upon wavelength and intensity of the radiant energy.

2.1 Describe photoionization and photodissociation (absorption processes).

2.2 Describe the ultraviolet range and subranges of light waves (UVA, UVB and UVC).

3.0 Be aware of and describe the damage that can be done to the skin by solar radiation.

3.1 Describe the anatomy of the human skin.

3.2 Describe and explain sunburn--short- and long-term effects.

4.0 State methods of preventing damage by sunburn (sunscreen).

4.1 Describe the properties of an ideal sunscreen (physical and chemical).

4.2 Relate the absorption of wavelengths to the effectiveness of chemical sunscreens.

4.3 Describe protection factor for chemical sunscreens.

Unit IV: Historical Development of the Atomic Theory

1.0 State reasons for the acceptance of the atomic molecular theory, i.e., x-ray diffracation in crystals, thickness of an oil film, brownian motion, concept of pressure, diffusion and definite proportions in chemistry.

2.0 State the early historical development of modern atomic theory including:
- . discovery of cathode rays;
- . discovery of x-rays;
- . discovery of the electron;
- . the Rutherford and Thompson models and the evidence or rejection of each.

3.0 Outline the development of the theory of quantum mechanics including:
- . Plancks equation ($E=h\nu$)
- . Hot Body Radiation
- . The Photoelectric Cell
- . The Bohr Atom
- . Waves of Matter

4.0 State the principles of radioactivity in terms of:
- . Becquerel's discovery
- . discovery of α and β rays and their properties
- . radioactive decay rates
- . radioactive decay patterns

5.0 Define the nature of isotopes in terms of their structure, relationship to elements, atomic weight, and radioactivity.

5.1 Describe and apply decay equations and transformation rules.

5.2 Describe artificial transmutation.

6.0 Describe evidence for the proton-electron-neutron model of the atom; the neutrino.

Option V: Earthquake Prediction

1.0 Describe the characteristics of earthquake waves and use these characteristics in the study of prediction methods.

1.1 List the parameters used to specify an earthquake prediction.

1.2 Describe the relationship between the Richter scale and magnitude of an earthquake.

1.3 Compare the success record of China and the U. S. in earthquake predictions.

1.4 List the properties of the three types of earthquake waves.

1.5 Explain what a travel-time graph shows.

2.0 State the theories about the causes of earthquakes.

2.1 Explain briefly the history of the theory of Continental Drifts.

2.2 Describe the current concepts about the mechanism of sea floor spreading.

2.3 List the five lines of evidence for plate tectonics.

2.4 Determine the drifting distances given rock polarity data.

2.5 Determine age and rate of movement given rock polarity data.

3.0 State various prediction methods and relationships.

3.1 List the mechanisms associated with the dilatency effect.

3.2 Explain recurrence rates and use a recurrence rate graph.

3.3 Use a graph relating uplift to magnitude.

3.4 Explain the significance of wave velocity changes.

3.5 List some of the observed abnormal animal behaviour prior to earthquakes.

3.6 Describe some of the uncertainties involved in issuing predictions.

Option VI: Energy Futures

Option VIa: Nature of the Resource

1.0 Define work, power and energy.

1.1 Apply formulae in work, power and energy relationships.

1.2 Describe ways in which energy can be converted from one form to another, e.g., chemical to electrical, mechanical to heat.

1.3 Define efficiency in energy systems and describe the input and output of some systems as related to efficiency, e.g., coal burning electrical generating plants or the automobile.

1.4 Describe energy costs in total systems such as producing food, metals, or in life systems.

2.0 Explain the formation of fossil fuels.

2.1 Describe the locations and potential extent of fossil fuel reserves.

3.0 Describe world and energy consumption (fossil fuels) relative to:

- energy consumption and its relationship to GNP
- energy consumption by various sectors of the economy, e.g., transportation
- comparative consumption among countries

3.1 Relate the effects of various factors upon predicting the availability of fossil fuels.

- define exponential growth and calculate its potential effect upon future availability of fossil fuels
- relate Hubbert's curves to estimating resource potential
- relate the potential effect of other factors upon resource availability, e.g., conservation
- critically analyze the arguments for conserving resources

Option VIb: Alternatives to Fossil Fuels

Nuclear Energy (Part 1)

1.0 Describe the characteristic properties of nuclear radiation (alpha, beta, and gamma).

1.1 Describe mechanisms for detecting radioactivity.

1.2 Describe the Rutherford model of the atomic nucleus, relate the model to the experimental data obtained and the basis for accepting this model.

1.3 Use isotope notation and relate this to the structure and possible isotopes.

2.0 Relate the stability of nuclei to factors such as binding energy and mass number.

2.1 Write nuclear equations.

2.2 Describe radioactive decay and relate decay to a nuclear model and transmutation.

2.3 Differentiate between nuclear fusion and fission.

2.4 Compare fusion and fission as controlled reactions to produce energy (advantages and disadvantages).

3.0 Relate nuclear binding energy to fission and fusion.

3.1 Compare energy changes associated with nuclear reactions.

3.2 Compare energy changes (phase, chemical, nuclear) in terms of quantity of available energy, application and technological possibilities at present.

4.0 Compare the CANDU system and other nuclear reactors (such as the U.S. LWR reactors), conventional power plants in terms of kinds of fuel used, processes (e.g., abosrption of particles mechanism, wastes produced, potential environmental effects; efficiency.

Extension

5.0 Describe the role of nuclear reactors relative to applications in nuclear chemistry:
- power generators
- research
- isotopes in agriculture and medicine
- the production of fuels (breeder reactors)

Alternative Sources (Part II)

1.0 Describe methods for harnessing renewable sources of energy such as wind, geothermal and tidal.

2.0 Interpret and evaluate the feasibility of alternative energy sources.

Option VII: Science, Technology and Society

1.0 Describe the effect of exponential growth upon:
- doubling time
- finite resources

2.0 Relate positive and negative feedback to growth and growth models.

3.0 Describe the interrelationships between finiteness of resources and growth (population, food and industrial requirements, resource development, environmental factors, technologies).

3.1 Relate feedback loops to both growth and steady state models.

3.2 Describe some of the weaknesses and strengths of the "Limits of Growth" model and describe some technological needs and alternatives.

4.0 Describe both the potential and the limitations of science and technology for resolving future problems.

4.1 Relate kinds of technology to factors such as replacement of people, size of technology, job satisfaction.

4.2 Describe a potential role for science in helping decision makers.

4.3 Describe the potential effects of microprocessors upon lifestyles of individuals.

5.0 Define quality of life and relate these to alternatives for resource use, individual activities, lifestyle or other factors affecting the future.

Option VIII: Special Relativity

1.0 Frames of Reference.

2.0 Galilean Transformation.

3.0 Postulates of Special Relativity.

4.0 Michelson-Morley Experiment.

5.0 Time Dilation (twin paradox).

6.0 Length Contraction.

7.0 Mass Increase.

8.0 Relativistic Addition of Velocities.

9.0 Lorentz Transformation.

10.0 Simultaneity of Events.

Option IX: Radiation and Some of its Biological Effects

1.0 Define radiation.

 1.1 Explain radiation as the emission of energy in wave or particle form.

 1.2 Identify the sources of natural radiation.

 1.3 Identify and name the various areas of the electromagnetic spectrum that are considered harmful radiation, e.g., x-rays, γ rays.

 1.4 Describe alpha, beta and gamma radiation in terms of their respective properties.

 1.5 Distinguish between particle radiation (alpha and beta) and wave radiation (gamma and x-rays).

2.0 Describe the quality and sources of ionizing radiation.

 2.1 Distinguish between radiation quality and source, e.g., electron radiation is a quality resulting from beta decay.

 2.2 In general terms, describe the operation of "man-made" sources and their products, e.g., cathode ray and x-ray tubes, particle accelerators.

3.0 State the effects of ionizing radiation.

 3.1 Describe the ionizing effect of radiation on an atom.

4.0 Define radioactive activity in terms of Curies and Becquerels.

 4.1 Define radiation exposure and exposure rate.

 4.2 Define radiation dose and dose rate.

 4.3 Define dose equivalent and equivalent rate.

5.0 Describe the use of the quality factor in assessing the biological effect of radiation.

 5.1 Explain the bearing the quality factor has on the amount of energy absorbed by biological matter.

6.0 Describe, in general terms, the detection techniques employed.

 6.1 Describe the operation of a pulse counter, e.g., Geiger Mueller Tubes.

 6.2 Describe the operation of pulse integration detectors, i.e., photo badges worn by nuclear research personnel.

7.0 Describe, in general terms, the biological effects of ionizing radiation.

 7.1 Relate the history of discovery of ionizing radiation.

7.2 Describe the three stages of radiation effects on biological matter.

7.3 Describe the genetic effects of radiation exposure:
- chromosome damage
- gene damage

8.0 Describe other short- and long-term biological effects of radiation.

8.1 Describe acute somatic effects.

8.2 Describe the radiation therapy used in treating cancer.

8.3 Describe the cancer-causing aspects of ionizing radiation.

9.0 Critically discuss the social implications of the nuclear age.

9.1 Evaluate media presentations.

9.2 Read and report on journal articles and research.

CURRICULUM ADOPTION AND IMPLEMENTATION

Curriculum adoption is the formal introduction of the curriculum guide, the purchase of new materials and the provision of orientation sessions. Curriculum adoption is distinguished from curriculum implementation, which is a long-term process involving several stages, requiring continuous commitment and action and resulting in measurable differences in classroom practices and student behaviour. Initial adoption of the new physics curriculum can begin in February, 1985, soon after the distribution of guides and the scheduling of in-service sessions. Officially, the new physics program will be adopted in September of 1985. Implementation will begin at the same time and is expected to take place in stages over a three-year period.

The purchase of new texts is normally a part of the adoption procedure which precedes the implementation phase. For Physics 200 and 300, however, the purchase of new materials may not be necessary at the beginning, but will not, in any case, take place until the second stage of implementation, after teachers have had an opportunity to assess the merits of new materials and test them in classroom practice.

THE ROLE OF THE TEACHER

Two implementation stages are recommended for the physics curriculum. In the first, teachers should become familiar with the rationale and general design of the program, the objectives, and some of the general implications of the change. Teachers should examine and try using in class some of the support materials to become familiar with their strengths and weaknesses, the ways which they can be used and combined, and the changes that may be necessary in laboratory activities. Working with the support materials will give teachers an opportunity to decide whether changes in teaching methods will be necessary.

For example, the least expensive way to begin to adopt the new program would be to retain present texts for core, supplemented with a single copy of Modern Physics and teaching Heat (Physics 200) and Optics (Physics 300) as options. During this time, familiarity with alternative materials could occur. An alternative would be to test Physic-Al: An Activity Approach for core (Physics 200) and old materials plus a copy of Modern Physics for core (Physics 300) and inexpensive options such as Facts (Physics 200) and Optics (Physics 300) could be attempted.

In the second stage, teachers should begin full-scale implementation of the new program, combining new materials with old texts, introducing new modules and laboratory activities and determining organizational needs and key activities for new topics. Some of the new units, such as Facts and Solar Energy, will likely involve organizational changes. The unit-design charts will provide more specific information regarding such changes.

Possible Time-Line

1985-86 Curriculum Adoption (familiarization with the objectives and the guide).
Development of a general plan for implementation.
Review of new materials; attempt of ideas from alternate core texts.
Attempt of one or more science, technology society units using sample materials as teacher resources.
Determination of new laboratory activities and equipment requirements.

1986-87 Full-scale curriculum implementation.
Introduction of science, technology, society units.
Definition of needs for alternate core texts and modules.
Purchase of materials for the above.

THE ROLE OF THE ADMINISTRATOR

Administrators may wish to familiarize themselves with the new curriculum and consider its implications for the purchase of new materials, whether they be alternate core texts or support materials for the option units.

Administrators can support the process of implementation by:

1) allowing time for the development of local expertise on alternate texts and options during the first year of implementation;
2) developing a plan for implementation based on specific needs, for example, the development of a local option to meet those needs and the science, technology, society objective (development could involve the cooperative effort of two or more schools);
3) providing a small emergency fund for obtaining simple, inexpensive laboratory materials locally (dry cells for meters for example).

SCOPE AND SEQUENCE OF PHYSICS 200, 300

PHYSICS 200 CORE	CONCEPTS	SKILLS
Kinematics	velocity, displacement and acceleration; speed and distance	analyze motion graphically; apply equations of motion
Vectors	define vectors	apply vector addition, subtraction, and resolution
Newton's laws	describe types of forces; describe and apply Newton's laws; define and use units of force	experimentally determine relationships between force, mass and acceleration
Circular motion	describe and apply concept of centripetal force; develop Kepler's and Newton's laws	analyze projectile motion; apply law of universal gravitation
Momentum-impulse	derive $F\Delta t=m\Delta v$; define Newton's Third Law; conservation of momentum; define and qualitatively describe motion of centre of mass	apply laws of conservation of momentum; apply equations of momentum change and impulse
Work-energy	define work and power; potential, kinetic, mechanical energy; energy transfer	apply energy equations to energy interchange
PHYSICS 300 CORE		
Waves	longitudinal and transverse waves; wave properties; interference	apply wave phenomena
Static electricity	nature of charge; charging by contact and induction	test and identify electrical charges
Fields and forces	force field; force between charges; capacitors; energy change and charged particles; electrical units	measurement of forces between charge; apply equations to energy exchange in moving charges
Basic circuits	Ohm's Law; series and parallel circuits; resistance in conductors (factors)	apply to various circuits
Basic magnetism	fields around conductors; field strength; ampere	measure and calculate forces on current carrying conductors
Induction and AC	Faraday's Laws; Lenz's Law; AC and induction; impedance; motors, generators and transformers	predict direction of induced e.m.f.

program implementation

INTRODUCTION

The Physics 200 and 300 program is no longer the text but the curriculum objectives stated in the first section of the guide. Teachers should refer to the program overview section for information on the expectations for the course and to the unit design charts for teaching ideas and suggested materials. Materials will vary in their capacity to support specific objectives.

TIME ALLOTMENTS

Time allotments for Physics 200 and 300 are 110 hours per course. The core portion of the program requires 80 to 85 percent of the available time. The remaining 15 to 20 percent is to be devoted to the option units. A minimum of one science, technology, society unit is to be completed per grade in that time.

STRUCTURE OF THE PROGRAM

Physics 200 contains six core units and one option unit. In general, the sequence of the core units suggested in the guide should be followed. Units from the option area could be completed at the end of the core, or some units, such as Facts, could readily be attempted early in the program.

Likewise, Physics 300 consists of six core units and one unit from the option area. The sequence of the core units should be followed as given. Depending on the choice of topics from the designed options, a topic can be related to specific core units or may be integrated into a number of units. Sound or Optics should be related to Waves or built into the Waves unit.

The core objectives for both Physics 200 and 300 are prescriptive and attempt to provide the necessary learning outcomes for students who intend to continue their studies in physics or related fields. For both, the sequencing of specific objectives within each unit can be modified according to materials used, the background of students or other variables.

The core portion of the program should be relatively familiar to physics teachers, except for Electricity and Magnetism. The option portion of the program which deals with the relationship of science, technology and society may contain relatively familiar content such as Motion, Earth and Sky or unfamiliar content such as Hydraulics or Solar Energy. It may also contain familiar techniques such as analyzing motion or such unfamiliar techniques as simulations (dealing with the comparison of alternative energy sources). Teachers should become familiar with the differences among the units and potential starting points in teaching a new unit. Piloting of the program indicated that there was sufficient time to develop both core and the options. Teachers in unsemestered schools had little difficulty in completing the course. Also, the core for Physics 300 requires slightly less time than does the core for Physics 200.

Flexibility to meet the varying needs and abilities of high school students is provided in the option units. There are designed units, from which one per grade must be chosen for completion. The units vary in complexity and in their emphases upon different aspects of the science, technology and society goal. Modules have been identified to support these units; these modules also offer a variety of approaches and different levels of complexity. Schools can complete their own local options as long as they meet the science, technology and societal goals.

LABORATORY ACTIVITIES

Laboratory activities have an important role in any science program which attempts to reflect the nature of the discipline, that is, both process skills and concepts. A minimum of eight laboratory experiments for Physics 200 and eight for Physics 300 is required. Laboratory activities from a specific laboratory guide are not recommended; rather, representative laboratory activities by topic are recommended as follows:

Physics 200 Core	Laboratory Activity
Unit 1	position and displacement
Unit 2	force vector sums
Unit 3	Newton's laws
Unit 4	analysis of motion in two dimensions and centripetal force
Unit 5	conservation of momentum (two labs)
Unit 6	conservation of kinetic and potential energy

Physics 300 Core	Laboratory Activity
Unit 1	waves (two labs)
Unit 2	electrostatics
Unit 3	Coulomb's Law
Unit 4	circuitry--Ohm's Law, series and parallel, nature of the conductor, electrical to mechanical energy conversion (three labs)
Unit 5	magnetic lines of force; magnetic field of a solenoid
Unit 6	electromagnetic induction; motors and generators; transformers (one lab)

Recommended laboratory activities are also suggested generally in the unit design charts.

Although the Physics Committee has attempted to monitor the recommended experiments for safety, teachers should review specific labs and should also be guided by safety considerations in making their own choices.

Laboratory activities are designed to develop skills in observing, classifying, quantifying, formulating hypotheses, making operational definitions, controlling and manipulating variables, interpreting data, formulating models, inferring, predicting, experimenting and communicating. In addition to these science process skills, there are some specific skills that students should develop in the laboratory.

GENERAL TOPICAL DESIGN FOR PHYSICS 200

HEAT

- nature of heat
- applications

SOLAR ENERGY*

- nature and variation in solar radiation
- technological ways to control solar energy
- advantages and disadvantages

FACTS

- nature of science

EXTENSION ONE
- statistical facts
- science and invention

EXTENSION TWO
- science-society interactions

CORE**

- linear kinematics
- vectors
- dynamics of motion--Newton's laws of motion
- dynamics of motion--circular motion
- momentum and impulse
- work and energy

MOTION: EARTH AND SKY

- motion: stars, sun, planets
- alternative models
- ways of knowing

FLUIDS AND HYDRAULIC DEVICES

- force and pressure
- Pascal's Principle
- applications

LOCAL OPTION

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* This unit could be combined with the Alternative Energy unit in Physics 300.

** Teachers should apply appropriate mathematical development throughout the course, e.g., graphical analysis.

GENERAL TOPICAL DESIGN FOR PHYSICS 300

SOUND

- properties
- hearing
- noise and control

OPTICS

- light principles
- optical instruments

LOCAL OPTION

SUNBURN

- solar radiation
- radiation damage
- prevention of solar radiation damage

EARTHQUAKES

- wave characteristics
- theories
- prediction methods and uncertainty of prediction

CORE

- waves
- static electricity
- fields and forces
- basic electrical circuits
- basic magnetism
- electromagnetic induction and alternating current

RADIATION AND SOME BIOLOGICAL EFFECTS

- quality and sources of radiation
- units and assessment of effect, detection
- biological effects--short- and long-term

SPECIAL RELATIVITY

- frames of reference
- postulates of special relativity
- consequences

NATURE OF THE ATOM

- structure of atom
- radioactivity
- fission-fusion applications

ENERGY FUTURES

- energy, conversion and costs
- factors affecting resource availability and analysis of potential effects
- uncertainty of resource prediction

ALTERNATIVES TO FOSSIL FUELS

- alternative sources; their technologies and potential
- risks and trade-offs

SCIENCE, TECHNOLOGY AND SOCIETY

- the future--exponential growth, feedback loops and other factors
- potential and limitations of science and technology on some societal aspects

RELATIONSHIP BETWEEN SUPPORT MATERIALS AND CORE OR OPTIONS

TEXTUAL MATERIALS	CORE		PHYSICS 200 OPTIONS					PHYSICS 300 OPTIONS									
	200	300	HEAT	SOLAR	FACTS	EARTH & SKY	FLUIDS	SOUND	OPTICS	SUN-BURN	EARTH QUAKE	NATURE OF ATOM	ENERGY		FUTURE	SPEC REL.	RADIA-TION
													SOURCE	ALTER			
Core																	
1. Modern Physics+	*	*	*					*	*								
2. PSSC Physics: 5th edition+	*	P				*			*								
3. Physic-Al: An Activity Approach	*																
Laboratory Manuals for Core																	
1. Laboratory Experiments in Physics: Modern Physics+	*	*															
2. Laboratory Guide PSSC Physics, 5th edition+	*	P															
Materials Supporting Options																	
1. Science in Society: Teacher's Guide					*								*		*		
2. Science in Society: Nature of Science					*												
3. Science in Society: Science and Social Development					*												
4. SISCON: How Can We Be Sure? and Teacher's Guide					*												

NOTE: The sources given in this chart are fully cited in Appendix A: Annotated Bibliography.

RELATIONSHIP BETWEEN SUPPORT MATERIALS AND CORE OR OPTIONS

TEXTUAL MATERIALS	CORE		PHYSICS 200 OPTIONS					PHYSICS 300 OPTIONS									
													ENERGY				
	200	300	HEAT	SOLAR	FACTS	EARTH & SKY	FLUIDS	SOUND	OPTICS	SUN-BURN	EARTH QUAKE	NATURE OF ATOM	SOURCE	ALTER	FUTURE	SPEC REL.	RADIA-TION
5. SISCON: Technology, Invention and Industry					*												
6. How to Lie with Statistics (teacher reference)					*												
7. Science and Society: The Meaning and Importance of Scientific Method (teacher reference)					*												
8. ALCHEM: Solar Energy				*													
9. Physics (teacher reference							*									*	
10. Motion in the Heavens						*											
11. The Nature of Light and Sound								*	*								
12. Sunburn and Sunscreens										*							
13. The New Physics												*					
14. Earthquake Prediction											*						
15. Energy in Perspective: 2nd edition													*	*			
16. ALCHEM: Nuclear Energy														*			

RELATIONSHIP BETWEEN SUPPORT MATERIALS AND CORE OR OPTIONS

TEXTUAL MATERIALS	CORE		PHYSICS 200 OPTIONS					PHYSICS 300 OPTIONS									
	200	300	HEAT	SOLAR	FACTS	EARTH & SKY	FLUIDS	SOUND	OPTICS	SUN-BURN	EARTH QUAKE	NATURE OF ATOM	ENERGY		FUTURE	SPEC REL.	RADIA-TION
													SOURCE	ALTER			
17. Science in Society: Energy														*			
18. SEEDS: Energy Technologies														*			
19. SEEDS: Energy in the Future														*			
20. Science in Society: Looking to the Future															*		
21. Radioactive Radiation and their Biological Effects																	*
22. Science in Society: Power Station Project Y														*			
23. Science in Society: Alternative Energy Project Y														*			

P: partial treatment of the area. See unit design for specific recommendations about particular materials needed.

+: Electricity and Magnetism Activities (a module). Manitoba Department of Education provides some alternative, inexpensive activities for electricity and magnetism.

Y: simulations which can be used to supplement or extend the "Alternative Energy" unit.

MATHEMATICAL PREPARATION*

The use and development of mathematical skills as part of the process of interpreting data and other forms of problem-solving has always been an important characteristic of education in physics. Although the skills can be isolated and taught as a special or introductory unit, it is probably more effective to integrate the development of necessary mathematical skills into the course design as needed and used. The following student skills are important to the teaching of a course in physics.

The student should be able to:

1. Gather, organize and interpret data obtained from an experimental situation.
2. Recognize the following functions:
   - a. linear ($y = mx + b$)
   - b. direct proportion ($y = cx$)
   - c. inverse proportion ($y = c \cdot 1/x$)
   - d. inverse square proportion ($y = c/x^2$)
   - e. direct square ($y = cx^2$)
   - f. direct square root ($y = c\sqrt{x}$)

   2.1 Distinguish between dependent and independent.

   2.2 Graph the necessary function to yield a straight line graph for each of the above functions.

   2.3 Compute the slope of the resulting straight-line graph in order to determine the constant of proportionality in each of the final "$y = cx$" type graphs.

   2.4 Write a final algebraic relationship employing the computed constant.
3. Use SI units of measurement in the areas of length, mass, and time. Convert measurements within SI.
4. Express measurements and perform mathematical operations in power-of-ten notation to the correct number of significant figures.
5. Estimate by using order-of-magnitude.
6. Write a laboratory report which includes purpose, data, and/or observations, and generalized conclusions.
7. Use the technique of dimensional analysis to: a) verify units; b) validate the problem-solving procedure employed, e.g., use of dimensional analysis to demonstrate that work and energy have equivalent units and are equivalent concepts.
8. Use simple trigonometric functions for right angled triangles (sine, cosine, tangent).

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* The materials entitled Physic-Al: An Activity Approach could serve as an excellent teacher or student reference illustrating the integration of the mathematical skills with the Physics 200 course.

SUPPORT MATERIALS

The purchase of a great number of new materials is not necessary in order to implement the new program. It is possible to use the texts currently in use to teach core for grade 11 and grade 12 and possibly the option, Motion--Earth and Sky. An additional option can be taught by using modules. For example, the grade 12 option on sound or optics could be developed by using the module, Nature of Light and Sound. This is the simplest and least expensive scheme.

Another possibility is to use Physic-Al: An Activity Approach to teach grade 11 core and materials presently in use to teach grade 12 core. The required options in both grades can be taught by using modules.

There are a number of other possible combinations as the correlation charts of materials and topics indicate. Teachers should become familiar with these possibilities during the first stage of implementation. Single copies of materials can be obtained and tested at that time. A limited number of samples is available in the Department of Education Library.

EVALUATION

Evaluation of student achievement and program effectiveness must be an integral, ongoing part of the teaching-learning process. Evaluation should provide information regarding:

1. Diagnosis and remediation. The purpose of diagnosis is to identify a student's strengths and weaknesses. If a weakness is found, the cause of the problem may then be identified and appropriate remediation provided by the teacher.

2. Student growth in mathematical skills and understanding. Monitoring student growth in mathematical skills is an integral part of a developmental program. Because growth is continuous, evaluation must also be continuous. Teachers should assess a student's speed and accuracy, understanding of concepts and processes and ability in applying skills. By constand evaluation a teacher can encourage further student attainment in science.

3. Learning strategies. Test results should be used to judge the effectiveness of the instructional process, program of experiences, materials of instruction and strategies of teaching.

4. Curriculum modification. Modifications should be ongoing. Therefore, continuing feedback from the schools regarding the appropriateness of the objectives and the degree of implementaion of the current program is essential.

Testing is a vital component of evaluation. Tests may be structured to evaluate a specific concept, a series of interrelated concepts, or all the concepts found in a year's work. Classroom teachers should design and use cumulative tests so that students maintain proficiency in previously learned concepts and skills.

Evaluation goes beyond paper and pencil testing. Evaluation of student achievement may include several additional functions, such as daily observation, interviews or conferences with individual students, class discussions, student reports and projects related to definitive and open-ended problem-solving situations.[1]

SPECIAL NEEDS STUDENTS

It is not expected that there will be students in either Physics 200 or 300 whose needs will require any substantial modification of the program. Flexibility has been designed into the course to allow for the variation in students' abilities and needs. Teachers can take advantage of the variety of teaching materials and strategies suggested in the guidelines to meet those needs.

TALENTED OR GIFTED STUDENTS

The Physics 200 and 300 outline identifies the minimum program for students. Students gifted in science are likely to meet the course objectives in less time than others do and may exhibit one or more of the following characteristics: 1) outstanding performance in most academic subjects; 2) prolific reading and the ability to understand scientific textbooks and articles; 3) preference for independent work with little teacher direction; 4) curiosity about abstract concepts; and, 5) willingness to assume responsibility.

Teachers of students gifted in science are faced with a challenge to enrich the program with stimulating and worthwhile activities. Suggestions for enrichment follow.

Stimulating Interest

- Provide a wide variety of materials and resources, such as the Science Teacher or Scientific American and other professional journals or magazines.
- Encourage reading in physics.
- Encourage the pursuit of problems of interest to the student.
- Use science clubs to maximum advantage.
- Organize seminars at which students can present papers and special projects for ultimate submission to journals and newspapers.
- Encourage peer tutoring.
- Encourage participation in science fairs.

Providing Meaningful Activity

- Provide access to mentors at post-secondary institutions.
- Enrich the program rather than accelerate the students.
- Provide independent activities.
- Encourage entry in physics contests and competitions.
- Promote computer use in physics.

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[1] Additional sources of information about evaluation can be found in William D. Hedges, Testing and Evaluation in the Secondary School (Belmont, CA: Wadsworth, 1966) and in Robert B. Sund and Anthony J. Richard, Behavioral Objectives and Evaluational Measures: Science and Mathematics (Columbus, OH: Charles E. Merrill, 1972).

- Encourage students to apply their physics to fields such as engineering, meteorology, environmental science, electronics and space science and medicine.

Developing Additional Skills

- Provide higher-level activities in problem solving, research, reading and writing skills than those required for regular programs.
- Emphasize the development of students' manipulative skills.

LABORATORY SAFETY

There is a safe way to perform all laboratory work. Just as in the concept of defensive driving as an accident-prevention approach, adequate planning and understanding can prevent injury in the laboratory. A convenient common-sense question to ask before performing an experiment is "What should happen if . . .?" Answers to this question require understanding of hazards associated with the materials and equipment involved. Thus, a knowledge of potential hazards and limitations of equipment dictate precautions to be taken. Such information might well form an introductory section to all written laboratory procedures.

The practice of safety in the laboratory requires: 1) the desire on the part of the individual for protection as well as protection of one's associates; and, 2) the need to follow a set of rules. The former can be termed safety morale, and is an essential part of accident prevention. The rules are usually enforced by implementing laboratory supervision. However, communicating these rules should be initiated through discussion with all physics students.

The prevention of accidents in a laboratory is the responsibility of every individual who enters it. For the teacher, there is a special responsibility, that is, to avoid the incident that could give rise to injury. In this context, laboratory safety is to be a positive component of science teaching, and the teacher should stress the importance of careful planning throughout the program. The result of this part of the physics program should be students with safety-conscious attitudes and behaviour. Since students tend to lack the instinctive feeling for investigative work that comes from long-term familiarity with the laboratory, they must be taught how to handle materials which are potentially harmful to them.

SAFETY RULES

There should be a limited number of rules for the laboratory, but what rules do exist must be rigidly and impartially enforced. Willful non-compliance should result in dismissal or suspension from the laboratory.

There are many specific dos and don'ts related to specific situations and activities. For further guidance, teachers are referred to Safety in Science (1982). For additional information, teachers are also referred to K. Everett and E. W. Jenkins, A Safety Handbook for Science Teachers, new edition. Don Mills: Academic Press Limited, 1976.

SAFE FACILITIES

The laboratory environment should be equipped with the appropriate safety devices and materials.

SAFETY RESPONSIBILITY

Each individual is responsible for performing his or her job safely. Untrained students or outsiders should not be permitted to work with materials except under adequate supervision. An instructor should be in the laboratory for the entire laboratory period.

Every teacher should:

1. Set a good example by: a) observing all rules and recommendations, b) wearing protective equipment where recommended, c) being enthusiastic about safety;
2. Be alert to unsafe conditions;
3. Take prompt corrective action for unsafe conditions;
4. Maintain discipline and enforce rules;
5. Prohibit the use of laboratory glassware for food or beverages--a dangerous practice;
6. Assume responsibility for visitors and require that they follow the same rules as students and other laboratory workers do;
7. Carefully review all laboratory experiments for possible safety problems before the experiments are assigned to students;
8. Maintain and encourage the use of a file of publications on laboratory safety, which is readily available to students, visitors and others.

A school science laboratory can be as safe a place in which to teach and learn as any location in the school. This will occur only through the constant vigilance of teachers and students alike.

THE INTERNATIONAL SYSTEM OF UNITS (SI) AND PHYSICS[2]

Over the centuries many different systems of measurement have been used throughout the world, but the one that is best suited to modern measurements is the metric system. Developed in France near the end of the eighteenth century, the metric system uses a decimal basis that makes it convenient to measure physical quantities. All the units in this system are related to smaller or larger units by dividing or multiplying by some factor of ten.

With the development of science and international cooperation, the availability of a uniform set of units has become important. In 1960, during the Eleventh General Conference on Weights and Measures, held in Paris, the SI (Système Internationale) units were defined and given status. Canada is now in the period of transition to these units.

The International System of Units is also called the MKS system because three of its fundamental units are the metre, kilogram and the second (measuring the three fundamental quantities--length, mass and time).

In SI, there are three kinds of units:

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[2] Source for much of the information in this section is the Metric Style Guide, Council of Ministers, 1975. Additional information can be obtained from the Science Teacher's Guide to Metrication, Curriculum Development and Implementation, Department of Education.

BASE UNITS

There are seven SI base units, the building blocks of the entire system. These were chosen to create a system of measurement that will not only meet our daily requirements, but also satisfy most of the needs of science and technology. The following table lists the seven base units of SI.

TABLE 1: SI BASE UNITS

Quantity	Unit	Symbol
length	metre	m
mass	*kilogram	kg
time	second	s
electric current	ampere	A
temperature	**kelvin	K
amount of substance	***mole	mol
luminous intensity	candela	cd

* The kilogram is the only base that has a prefix. The gram proved to be too small for most practical purposes.

** The base unit of temperature is the kelvin, but in everyday life, the degree Celsius is used instead.

*** The mole is used mostly in the field of chemistry.

Definitions of the Base Units

The metre is the length equal to 1,650,763.73 wavelengths in a vacuum of the radiation corresponding to the transition between the levels $2p_{10}$ and $5d_5$ of the krypton-86 atom.

The kilogram is equal to the mass of the international prototype of the kilogram kept at the International Bureau of Weights and Measures.

The second is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.

The ampere is that current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 m apart in vacuum, would produce between these conductors a force equal to 0.2 µN/m of length.

The kelvin, the unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water. Note: the triple point of water has a temperature of 0.01°C, hence °C corresponds to 273.16°K.

The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kg of carbon-12.

The candela is the luminous intensity, in the perpendicular direction, of a surfce of 1/600,000m^2 of a black body (full radiator) at the temperature of freezing platinum under a pressure of 101.325 kPa.

SUPPLEMENTARY UNITS

There are two supplementary units: the radian and steredian. They are used for measuring plane and solid angles, and are used sparingly in this program, but are used extensively at post-secondary levels.

DERIVED UNITS

A large number of units used in physics is derived from one or more base units.

The derived unit of acceleration is the metre per second squared (m/s^2). It is used, for example, to measure the rate at which a car gains speed. If a traffic light turns green and a car reaches the urban speed limit (50 km/h or 14 m/s) in about 7 s, it accelerates at roughly 2 m/s^2. A falling stone gains speed at about 10 m/s^2.

There are many other derived units with compound names--names that show how they are formed from base units. The following table shows some of them.

TABLE 2: SOME DERIVED UNITS WITH COMPOUND NAMES EXPRESSED IN TERMS OF BASE UNITS

Quantity	Unit (Compound Name)	Symbol
area	square metre	m^2
volume	cubic metre	m^3
speed	metre per second	m/s
acceleration	metre per second squared	m/s^2
density	kilogram per cubic metre	kg/m^3
momentum	kilogram metre per second	kg.m/s
angular momentum	kilogram metre squared per second	$kg.m^2/s$
specific volume	cubic metre per kilogram	m^3/kg
luminance	candela per square metre	cd/m^2

Derived Units With Special Names

Some derived units are given special names for the sake of simplicity. For instance, the derived unit of power, expressed in terms of base units, is the kilogram metre squared per second cubed. This is simply called the watt, familiar to us in electric light bulbs and appliances. The following are examples of some derived units with special names.

The derived unit of force is called the newton (N), which is named after the English scientist, Sir Isaac Newton. The newton is roughly the force required by your hand when supporting two golf balls or a flashlight battery (one D cell). In SI, all forces are stated in terms of the newton, which is rather a small force. Multiples of this derived unit, such as the kilonewton and meganewton occurs in industry. If you can lift a 100-kg heavy-weight boxer off the floor, you must exert a force of about a kilonewton (kN) to do so.

The derived unit of pressure is called the pascal (Pa). It is equal to a newton per square metre (1 Pa = $1N/m^2$). This is a low pressure equal to that which is exerted by about 100 mL of sugar when spread evenly over the surface of a card table. Multiples of the pascal, such as the kilopascal and the megapascal, will be useful units of pressure. The air pressure required in a standard car tire is about 200 kPa, normal pressure is about 100 kPa, and normal human blood pressure lies between 10 and 20 kPa.

The derived unit of energy is the joule (J). It equals a newton metre (1 J = 1 N.m). If two golf balls are lifted through a height of 1 m, then 1 J of work has been done.

A young woman, climbing a one-storey stairway, expends about 1.5 kJ of energy, but if she had previously eaten a piece of apple pie, she would have absorbed about 1 200 kJ, thus having plenty of energy to spare.

The derived unit of power is the watt (W), which is exactly one joule per second (1 W = 1 J/s).

The power rating of a car engine is given in kilowatts, not horsepower.

The derived unit of frequency is the hertz (Hz), the SI name for cycle per second. A frequency of 60 cycles per second is referred to as 60 Hz. "1010 on your dial" means a radio frequency of 1010 kHz, formerly called 1010 kilocycles per second.

The following table shows some derived units.

TABLE 3: SOME DERIVED UNITS WITH SPECIAL NAMES

Quantity	Unit	Symbol	Derivation
frequency	hertz	Hz	1/s reciprocal time
force	newton	N	$kg.m/s^2$ mass x acceleration
pressure	pascal	Pa	N/m^2 force per area
energy, work	joule	J	N.m force x displacement
power	watt	W	J/s energy per time
electric charge	coulomb	C	A.s current x time
electric potential	volt	V	J/C energy per charge
electric resistance	ohm	Ω	V/A potential difference per current
luminous flux	lumen	lm	cd.sr luminous intensity of source x solid angle of radi-

NOTE: The derivation of a unit is necessarily unique. For example, the volt may be defined as one watt per ampere (W/A).

More SI derived units with special names are formed in much the same manner as the newton, pascal, joule, watt and hertz. For example, in electrical work, one coulomb = one ampere second, one volt = one joule per coulomb, one ohm = one volt per ampere and so on, each unit being a product and/or quotient of other units that are already formed in the same manner from the set of base units.

TABLE 4: METRIC UNITS NOT TO BE USED WITH SI

Obsolete Unit & Symbol	Value and Application	
micron (μ)	1 μ = 10^{-6}m	length
kilogram-force (kgf)	1 kgf = 9.8 N	force
dyne (dyn)	1 dyn = 10^{-5}N	force
calorie (cal)	1 cal = 4.19 J	energy
erg (erg)	1 erg = 10^{-7}J	energy

Some others in this category are the oersted, the maxwell and the gauss.

Definitions of Derived Units With Special Names

One hertz is the frequency of a periodic occurrence which has a period of 1s. This unit was called the cycle per second. (1 Hz = 1 s^{-1})

One newton is the force which, when applied to a mass of 1 kg, gives it an acceleration of 1 m/s^2. (1 N = 1 $kg.m/s^2$)

One pascal is the pressure resulting from a force of 1 N acting uniformly over an area of 1 m^2. (1 Pa = 1 N/m^2)

One joule is the work done when the point of application of a force of 1 N is displaced through a distance of 1 m in the direction of the force. (1 J = 1 N.m)

One watt is the power available when energy of 1 J is expended in 1 s. (1 W = 1 J/s)

One coulomb is the charge transported in 1 s by a current of 1 A. (1C = 1 A.s)

One volt is the difference in potential between two points of a conducting wire carrying a constant current of 1 A, when the power dissipated between these points is equal to 1 W. (1 V = 1 W/A)

One farad is the capacitance of a condenser having a charge of +1C on one plate and -1C on the other plate and a potential difference of one volt across the plates. (1F = 1 C/V)

One ohm is the resistance between two points of a conductor when a constant difference of potential of 1 V applied between these two points produces in this conductor a current of 1 A, the conductor not being the source of any electromotive force. (1Ω = 1 V/A)

SI MULTIPLES AND SUB-MULTIPLES

SI is made up of base, supplementary and derived units; these could be used to express all required measurements. However, very large and extremely small measures would then involve cumbersome numbers. The distance from the sun to Pluto would have to be shown as 6,000,000,000,000 m and the mass of a bee's wing as 0.000,000,05 kg. These measures can be expressed exponentially: 6 x $10m^2$ and 5 x 10^{-5}g.

To avoid such numbers, decimal prefixes can be added to SI units; the above measures then become 6 Tm (terametres) and 50 g (micrograms), respectively. Using the prefixes tera and micro saves writing a numerous zeros.

TABLE 5: SI PREFIXES

Prefix	Symbol	Factor by which the unit is multiplied
exa	E	1 000 000 000 000 000 000 (Proposed) = 10^{18}
peta	P	1 000 000 000 000 000 (Proposed) = 10^{15}
tera	T	1 000 000 000 000 = 10^{12}
giga	G	1 000 000 000 = 10^{9}
mega	M	1 000 000 = 10^{6}
kilo	k	1 000 = 10^{3}
hecto	h	100 = 10^{2}
deca	da	10 = 10^{1}
		1 = 10^{0}
deci	d	0.1 = 10^{-1}
centi	c	0.01 = 10^{-2}
milli	m	0.001 = 10^{-3}
micro	μ	0.000 001 = 10^{-6}
nano	n	0.000 000 001 = 10^{-9}
pico	p	0.000 000 000 001 = 10^{-12}
femto	f	0.000 000 000 000 001 = 10^{-15}
atto	a	0.000 000 000 000 000 001 = 10^{-18}

TABLE 6: SI UNITS NAMED AFTER SCIENTISTS

Unit	Scientist	Country of Birth	Dates
ampere	Ampere, André-Marie	France	1775-1836
coulomb	Coulomb, Charles Augustin de	France	1736-1806
degree Celsius	Celsius, Anders	Sweden	1701-1744
farad	Faraday, Michael	England	1791-1867
henry	Henry, Joseph	United States	1797-1878
hertz	Hertz, Heinrich Rudolph	Germany	1857-1894
joule	Joule, James Prescott	England	1818-1889
kelvin	Wm. Thomson, Lord Kelvin	England	1824-1907
newton	Newton, Sir Isaac	England	1642-1727
ohm	Ohm, Georg Simon	Germany	1787-1854
pascal	Pascal, Blaise	France	1623-1662
siemens	Siemens, Karl Wilhelm later Sir William	Germany (England)	1823-1883
tesla	Tesla, Nikola	Croatia (United States)	1856-1943
volt	Volta, Count Alessandro	Italy	1745-1827
watt	Watt, James	Scotland	1736-1819
weber	Weber, Wilhelm Eduard	Germany	1804-1891

physics 200 (core)

UNIT 1: LINEAR KINEMATICS TIME: 20 Hours

RATIONALE: Linear kinematics is used to introduce the student to some of the fundamental terms and concepts which underlie motion and provides the basic scientific and mathematical interpretations of ideas which can serve as a foundation for later studies of motion.

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Distinguish between the following terms: . displacement and distance (d) . velocity (v) and speed	Pull a paper tape through a vibrating clapper such that the acceleration will be constant (e.g., drop an object which will pull the tape). - Graph d vs. t - Graph v vs. t - Graph a vs. t - Compute the average v from the slope of the d vs. t graph - Compute the average a from the slope of the v vs. t graph - Compute v from the area under the acceleration versus time graph A laboratory activity dealing with position and displacement is recommended.	Modern Physics Chapter 3, "Nature and Causes of Motion" 3.1, "The Nature of Motion" 3.2, "Speed" (define and illustrate) 3.3, "Velocity" (v) 3.4, "Working Velocity Problems" Physic-Al: An Activity Approach Units A and B, "What is Physics?", "Motion" PSSC Physics, 5th ed. "Linear Kinematics" 1.1, "Position and Displacement Along a Straight Line" (Explain the term displacement.) 1.2, "Steady Motion-Constant Velocity" 1.3, "Instantaneous

OBJECTIVE	NOTES TO TEACHERS	
2.0 Define acceleration and analyze motion graphically.		Velocity" 1.4, "Velocity-Time Graphs from Position-Time Graphs"
2.1 Graph "d vs. t," "v vs. t" and "a vs. t."	Provide sample data and graphs for student analysis. Correlations between the conclusions pertaining to the slopes and areas (from the analysis of motion) and the equations of motion should be made. Students should be able to find slopes of lines for linear graphs only. For graphs which are curves, the teacher can illustrate how to find instantaneous velocity or acceleration by drawing a tangent and finding the slope.	Modern Physics 3.5, "Nature of Acceleration" Giancoli, Physics Chapter 1
2.2 Apply the equations of motion (which the teacher has "derived"). . $d = \frac{(v_1 + v_2)t}{2}$. $v_f = v_i + at$. $v_f^2 = v_i^2 + 2ad$. $d = v_i t + \frac{1}{2} at^2$	Correlations between the conclusions pertaining to the slopes and areas (from the analysis of motion) and the equation of motion should be made.	Modern Physics 3.6, "Uniformly Accelerated Motion" PSSC Physics, 5th ed. Film, "Straight Line Kinematics" Exercises and Experiments in Physics: Modern Physics Experiment 3, "Measuring Time" Experiment 4, "Acceleration"

OBJECTIVE	NOTES TO TEACHERS	
		Experiment 5, "Acceleration II" (only if equipment is available) PSSC Physics, 5th ed. 1.6, "Acceleration" PSSC Physics Laboratory Guide, 5th ed. "Motion: Velocity and Acceleration"
2.3 Apply the equations of motion to freely falling bodies using "g."	A demonstration can be done which includes a stroboscopic photograph of a free-falling object or with a ticker tape and/or Project Physics film loops. "Acceleration Due to Gravity I" and "Acceleration Due to Gravity II." The approximate value for "g" can be found by using water drops falling on a pie plate and adjusting time interval for a drop to form (using a stopclock) and time for a drop to hit the plate.	Modern Physics 3.7, "Freely Falling Bodies" College Physics Series: Volume 3 Cross Educational Software, 1802 N. Trenton Street, Reston, L.A. (use on APPLE 48K) Gravitational Potential Energy is available from Merlan Scientific Ltd.

UNIT 2: VECTORS

TIME: 10 Hours

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:	Students will have to be taught trigonometric functions, sine, cosine and tangent for determining angles. They could also be taught to determine angles graphically. Possible review of $h^2 = a^2+b^2$ will also be required along with trigonometric work.	
1.0 Apply vector addition to linear problems.	Use elastics and spring balances to determine the sum of two vectors. Illustrate with two examples.	Modern Physics 4.2, "Combining Force Vectors"
	A laboratory exercise dealing with force vector sums is recommended.	Physic-Al: An Activity Approch Unit D, "Motion in Two Dimensions"
	More extensive treatment of vectors should be done here. Apply vector addition and subtraction and resolution of vectors. Use force vectors as in text but also bring in velocity vectors from earlier study.	
2.0 Define vector subtraction as vector addition with a negative vector and apply to problems; apply vector subtraction using the tail-to-tail method.	Show how vector subtraction applies to velocity changes and relative velocity. Show how the tail-to-tail methods are often more convenient when finding velocity.	PSSC Physics, 5th ed. 3.1 to 3.4

OBJECTIVE	NOTES TO TEACHERS	
3.0 Use scale diagrams to solve for a vector sum or difference.	Use the diagram-scale method for vectors as the primary approach and trigonometric methods as a second approach (used only for right triangles).	PSSC Physics, 5th ed. 3.1 to 3.4 PSSC Films, "Vectors" and "Vector Kinematics"
4.0 Resolve a vector into components using: . scale diagram method . trigonometric method	The motion of two-dimensional situations such as a boat or aircraft moving at prespecified speeds can be resolved into right-angled components.	Giancoli, Physics 1.6

UNIT 3: DYNAMICS OF MOTION--NEWTON'S LAWS OF MOTION

TIME: 15 Hours

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Describe different types of forces which exist in nature.	Consider the following forces: - gravitational - electromagnetic - nuclear	
2.0 Determine, experimentally, by using a low friction device, e.g., an air table, whether zero force yields zero acceleration and determine the same way (and graphically), the relationship between force (F) and acceleration (a), e.g., F=Ma. The law of inertia can be shown.	Discuss with students the possible effect of friction. The concept of the coefficient of friction could be included.	Physic-Al: An Activity Approach Unit C, "Forces" Modern Physics "Newton's Laws of Motion-State" 3.8, "Laws of Inertia" 3.9, "Law of Acceleration" Films available from the Department of Education Library: "Inertia of Motion" "Inertial Mass" "Inertia" PSSC Physics, 5th ed. 2.1 to 2.8, "Newton's Laws of Motion" 4.1 and 4.2, "Weight and Free Fall"
2.1 Describe and apply Newton's first and second laws of motion.		

OBJECTIVE	NOTES TO TEACHERS	
		PSSC Physics Laboratory Guide, 5th ed. Experiment 3, "The Dependence of Acceleration on Force and Mass" Experiment 4, "Inertial and Gravitational Mass" Experiment 5, "Forces Acting at an Angle"
3.0 Define the appropriate units of force (e.g., the newton) . define weight	i.e., $W = mg$, 1 Pascal = 1 newton/m^2.	*Modern Physics* 3.10, "Law of Interaction"
4.0 Define Newton's Third Law in qualitative terms by using examples.	This law can be introduced by using simple demonstrations or experiments which relate mass to acceleration. Momentum and impulse is developed in a later unit.	*PSSC Physics*, 5th ed. 3.9 and 3.10, "How Forces Add: The Net Force" Giancoli, *Physics* Chapter 3 (omit 3.1)

UNIT 4: DYNAMICS OF MOTION--CIRCULAR MOTION

TIME: 15 Hours

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Analyze projectile motion emphasizing the independence of horizontal and vertical motion.	Analysis of the motion of an object in projectile motion should be used to develop vector resolution and motion in two dimensions. This analysis should be made from a stroboscopic photo. Laboratory activities on analysis of motion in two dimensions and centipetal force are recommended.	Physic-Al: An Activity Approach Unit E, "Accelerated Motion in Two Dimensions" PSSC Physics Labatory Guide, 5th ed. "Forces on a Ball in Flight" NOTE: Stroboscopic photo includes air friction. PSSC Physics, 5th ed. 4.4, "Idealized Projectile Motion" Modern Physics 5.1, "Motion in a Curved Path" Film available from Department of Education Library: "Free Fall and Projectile Motion"

OBJECTIVE	NOTES TO TEACHERS	
2.0 Describe that the force causing circular motion (centripetal force) is a centre-directed force which causes a constant centre-directed acceleration.	Perform the experiment where the relationships between T and F, T and m, T and R are found to yield $F=CmR/T^2$ and mathematically prove this to be correct. As well, derive $c=4\pi^2$. Furthermore, show that $F=mv^2/R$.	Modern Physics 5.2 to 5.4, "Motion in a Circular Path" to "Frames of Reference"
3.0 Apply the concept of centripetal force to practical examples.		Exercises and Experiments in Physics: Modern Physics Experiment 9, "Centripetal Force" PSSC Physics, 5th ed. 3.7 and 3.10, "Circular Motion" and "The Vector Nature of Newton's Law" PSSC Physics Laboratory Guide, 5th ed. Experiment 6, "Centripetal Force" Physics, A Human Endeavour: Motion in the Heavens, Giancoli, Physics. Chapter 3
4.0 Develop Kepler's laws of planetary motion.	The PSSC film, "Universal Gravitation," can be used to introduce these concepts.	

OBJECTIVE	NOTES TO TEACHERS
5.0 Develop Newton's Law of Universal Gravitation from Kepler's Law.	
6.0 Apply the Law of Universal Gravitation to a variety of situations.	PSSC Physics, 5th ed. 4.9 and 4.10, "Newton's Law and the Rotation of the Earth" and "Newton's Law and a 'Coasting' Spacecraft"
7.0 Use Kepler's Law of Periods. $K = R^3/T^2$, the formula for circular motion, and $4\pi^2 K = GM$ to arrive at $F = GM_1M_2/R^2$.	5.1 to 5.6, "The Gravitational Field Near the Earth" to "Laboratory Tests of the Law of Universal Gravitation"

UNIT 5: MOMENTUM AND IMPULSE TIME: 10 Hours

OBJECTIVE	NOTES TO TEACHERS	
The students should be able to: 1.0 Describe, qualitatively, the nature of impulse and momentum.		
1.1 Derive $F\Delta t = m\Delta v$ from Newton's Second Law.	Review $F=ma$, $F=ma$---- $F= \Delta V/\Delta t$; $F\Delta t=M\Delta V$.	Physic-AI: An Activity Approach Unit G, "Impulse and Momentum"
1.2 Apply "impulse equals change in momentum" to situtions where the force is not constant, but is changing linearly, e.g., area under a linear "Ft" graph.	Solve problems using impulse-change and momentum where the force is constant. Laboratory activities (2) on conservation of momentum are recommended. Solve problems using "Ft" graphs proceeding from a constant force to a graph where the force is increasing or decreasing linearly.	Modern Physics 6.12, "Nature of Momentum," 6.13, "The Conservation of Momentum" PSSC Physics, 5th ed. 6.1 to 6.6 For interest, use sections 8.6, "Escape Energy" and 8.7, "Total Mechanical Energy"
1.3 Apply the equations of momentum change and impulse (teacher derived).		Exercises and Experiments in Physics: Modern Physics Experiment 14, "Conservation of Momentum"

OBJECTIVE	NOTES TO TEACHERS	
2.0 Define Newton's Third Law both in qualitative and quantitative terms.		PSSC Physics Laboratory Guide, 5th ed. Experiment 9, "Momentum Changes in an Explosion" Experiment 10, "A Collision in Two Dimensions" Experiment 11, "Throwing a Baseball"
3.0 Apply the laws of conservation of momentum qualitatively to linear explosions.		
4.0 Qualitatively describe conservation of momentum in non-linear explosions.		
5.0 Apply the law of conservation of momentum to collisions between two masses in one and two dimensions.	Perform the "collision in two dimensions" experiment from the PSSC Laboratory Book.	
5.1 Define the centre of mass.	Perform conservation of momentum experiments in one dimension. Use some simple cases (two-point objects) and work through the necessary calculations to illustrate that the centre of mass maintains its momentum and velocity. Solve problems in locating centre of mass in a two-body system, e.g., stroboscopic photographs in the PSSC Physics, 5th ed.	Films available from the Department of Education Library: "Elastic Collisions and Energy" "Collisions of Hard Spheres"
5.2 Locate the centre of mass for a two-body system.		
5.3 Qualitatively describe the motion of the centre of mass in explosions and collisions (one-dimensional only).		

UNIT 6: WORK AND ENERGY TIME: 10 Hours

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Define work and power in terms of: (1) Work = Force x Distance; (2) Power = Work/Time; and, (3) Power = Fxv. 1.1 Define work as the area under a force-distance graph. Interpret graphs.	For work, use 1N.m = 1 joule and for power, use 1 joule/second = 1 watt. Solve problems (work and power generated) using cars, electric motors and athletes. Have students run up a set of steps and determine work and power. A laboratory activity on conservation of kinetic and potential energy is recommended.	Physic-Al: An Activity Approach "Work and Energy" Modern Physics 6.1, "Definition of Work," 6.2, "Work Done by Varying Forces," and 6.5, "Definition of Power" Exercises and Experiments in Physics: Modern Physics Experiment 12, "Power" PSSC Physics, 5th ed. 7.1, 7.2, 7.3, 7.5, 7.8
2.0 Define two types of mechanical energy: kinetic energy and potential energy.	Teachers should derive the formula for kinetic energy ($\frac{1}{2}mv^2$) and potential energy ("Mah" where "a" represents acceleration due to gravity and $\frac{1}{2}kx^2$, the potential energy of a spring). Solve problems in finding kinetic and potential energy for gravitational and spring situations.	Modern Physics 6.7, 6.8, 6.10, 6.11, "Gravitational Potential Energy," to "Conservation of Mechanical Energy", and 7.10, "Elasticity"

OBJECTIVE	NOTES TO TEACHERS	
3.0 Describe the energy transfers that occur during an interaction involving both potential and kinetic energy.	Solve problems and laboratory activities such as "Elastic Potential Energy." Simple harmonic motion should be left out.	Exercises and Experiments in Physics: Modern Physics Experiment 13, "Elastic Potential Energy" PSSC Physics, 5th ed. 8.1, 8.4, "The Spring Bumper" and "Gravitational Potential Energy Near the Surface of the Earth"
4.0 Quantitatively apply the principle of mechanical energy to elastic collisions.	Use a dynamics cart with a spring bumper striking a rigid object to show that kinetic energy is "conserved" as potential energy during a collision, or use a stroboscopic photograph to analyze a motion. Apply the concepts of energy to solve a range of problems in mechanics such as throwing a baseball.	PSSC Physics Laboratory Guide, 5th ed. Experiment 11, "Throwing a Baseball"
5.0 Quantitatively distinguish between elastic and inelastic collisions.	Use sample problems illustrating the difference.	

physics 200 (options)

OPTION I: FACTS AND INFORMATION ANALYSIS TIME: 10-20 Hours

RATIONALE: If an individual is to make decisions about the behaviour of matter in a specific situation or about the potential usefulness of an alternative energy resource such as solar energy (a much broader question), the individual must be able to interpret and evaluate the relevance of the information or data which is associated with the question. The difference between facts and opinions, observed and inferred facts, the nature of scientific hypotheses and laws, uncertainty of data, and the nature of logic are important concepts to develop. This unit is designed to provide a basic (or core) set of ideas or experiences which relate facts to opinions, uncertainty and generalizations. Depending upon the interest and needs of the student, at least two possible kinds of development beyond this base can be attempted. The two possible alternatives contain the following directions or emphases:

Extension One

Additional understanding of the uncertainties involved in obtaining and interpreting data can be developed beyond the basic (or core) set of ideas. This includes examining extrapolation, statistical data, risk and other means of interpreting information. The nature of science as a "way of knowing," uncertainties in science, and the relationship of science to other "ways of knowing" can be examined.

Extension Two

The interaction among science, technology and society can be examined.

If alternative one is chosen, the teacher may wish to use this unit early in the course. In addition, the content of this unit is extensive and broad. Depending on students' interest and the teacher's knowledge, the teacher may prefer to concentrate on certain portions rather than on the total unit.

PRIMARY REFERENCES:

1. Lewis, John L. (project director). Science in Society: Teacher's Guide. London: Heinemann Educational Books Ltd., 1981.

OR

2. Solomon, Joan. SISCON: How Can We Be Sure? (and teacher's guide). Oxford: Basil Blackwell Publishers Ltd., 1983.

EXTENSION ONE

1. Lewis, John L. Science in Society: Nature of Science (Book J). London: Heinemann Educational Books Ltd., 1981. Also teacher copies only of How to Lie with Statistics and Science and Society: The Meaning and Importance of the Scientific Method. (See references below.)

OR

2. Solomon, Joan. SISCON: Technology, Invention and Industry. Oxford: Basil Blackwell Publishers Ltd., 1983.

AND

Huff, Darrell. How to Lie with Statistics. New York: W. W. Norton and Company (pb.), 1954. (Teacher copy only.)

AND

Bassey, Michael. Science and Society: The Meaning and Importance of the Scientific Method. London: University of London Press. (Canadian representative: Dominie Press Limited, Agincourt, ON.) (Teacher copy only.)

EXTENSION TWO

1. Lewis, John L. Science in Society: Science and Social Development (Book K). London: Heinemann Educational Books Ltd., 1981.

SUPPLEMENTARY REFERENCES:

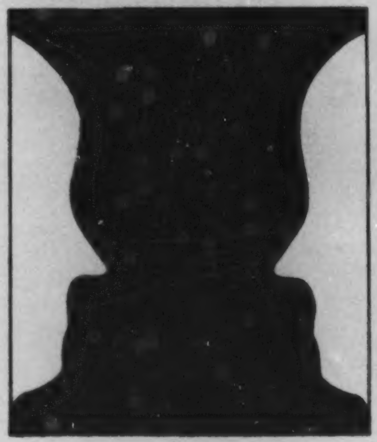
1. Matthews, William H. et al. Investigating the Earth, third edition. Boston: Houghton Mifflin Co., 1978.
2. Biological Sciences Curriculum Study. Energy and Society: Investigations in Decision Making. Northbrook, IL: Hubbard, 1977. (This publication would also be useful in the Energy options in Grade XII.)
3. Giancoli, Douglas C. The Ideas of Physics: SI Edition. Don Mills: Academic Press Canada, 1981.

AUDIO-VISUAL MATERIALS (Department of Education)

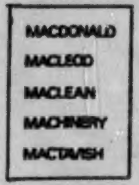
1. "How Safe Is Enough?" and On the Perception Estimation and Evaluation of Risk: Teacher's Guide to the film "How Safe Is Enough?"

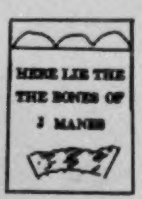
OBJECTIVE	NOTES TO TEACHERS	
The student should be able to: CORE		
1.0 Distinguish and describe the differences among: . facts and value judgements or opinions;	Discuss the differences by using examples from Bassey's idea that "a fact is a fact, but the statement of the fact may be inaccurate; thus, the stress should be on examinating the description of the fact and whether it is faulty." For example, the following statements could be examined in terms of fact, value, likelihood of accuracy. . I feel this thing on which I am writing. . This thing is a desk. . This desk cost me $90. . Ninety dollars is a lot of money. . This desk is a work of art. . This desk is really an armchair. Other statements from reports of scientific discoveries could be examined on a similar basis.	Bassey, Science and Society Science in Society: (Teacher's Guide) "What are the Facts?" SISCON: How Can We Be Sure? Science in Society: Nature of Science "Being Scientific" Energy and Society: Investigations in Decision Making "Analyzing and Interpreting Data" Laboratory Manual Chemistry: Experiments and Principles "Scientific Observation and Description"
. direct and indirect observations; . observed and inferred facts;	Observe the properties of a burning candle to differentiate between student observations and inference. The laboratory report of this experiment is available in many chemistry laboratory manuals.	

OBJECTIVE	NOTES TO TEACHERS
	Discuss the observed fact that "cobwebs are present in a home" and possible inferences about the presence of a spider, or the assumed laziness of the homemaker. The concept of a hypothesis as being less certain than a fact without more corroborative evidence could be introduced.
. historical and scientific facts.	Discuss the difficulty of repeatability and accuracy in recording historical facts and compare the use of these criteria in evaluating direct and indirect observation. This can be used to introduce the concept of uncertainty in observation and reporting. Have students bring different newspaper reports about the same event and analyze them. Statements can be analyzed or categorized as: Statements Factual Statements observed inferred historical Hypotheses true false Value Judgements moral aesthetic You may wish to cooperate with the social studies teacher in dealing with the problem of historical fact and how it is dealt with. Bassey, in Science and Society, writes about the following reports of an event: ". . . he was wearing blue wrestling shorts under his kilt" (Lancashire Post) ". . . his kilt came apart, revealing a pair of tartan shorts" (Daily Express) ". . . John Bland . . . jumped to his feet minus kilt, but wearing trews" (Daily Sketch)

OBJECTIVE	NOTES TO TEACHERS
1.1 Describe some difficulties in obtaining or accepting observed fact on the basis of perception and stored knowledge.	Discuss, with students, examples of the effect on observing of perception and previous knowledge. . Use pictures to obtain student's results of perception and observation. What facts do they see? The Man? The Shape? 

OBJECTIVE	NOTES TO TEACHERS

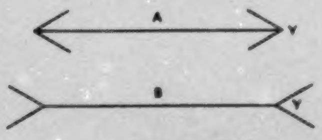




Have students read the inscriptions. Ask students to bring in or suggest other examples. Some are suggested in the Grade X mathematics program.

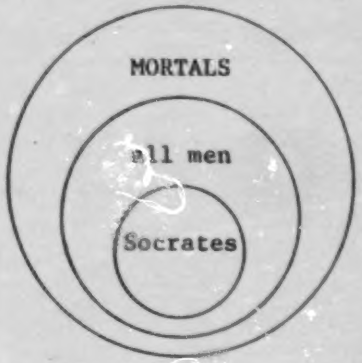
According to Bassey, a leading French astronomer named Lalonde noted in 1795 a new "star" on two separate occasions, but at different positions. This suggested the existence of a body nearer to Earth than the stars are. On the basis of his experience, he rejected the observation as a new planet. Neptune was later discovered in 1846 because of observed irregularities.

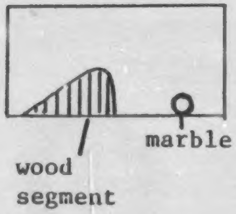
The film, "Frames of Reference," available from the Department of Education Library, is an alternative way to introduce the idea of how perception can affect observation and hypotheses. For example, early astronomers had problems with observation because of a moving frame of reference. The film could also be used to illustrate how observations of motion are affected.



Draw "A" and "B" on the board with "A" longer than "B." Ask students to predict length and then check measurements. Because many students have met this before as two equal lines, they may tend to stay with that observation.

The Ideas of Physics
"Relativity"

OBJECTIVE	NOTES TO TEACHERS	
1.2 Compare deductive and inductive methods.	Develop the ideas in simple terms at the beginning since they will continue to be developed within the unit. Use Venn diagrams to illustrate deductive logic on such statements as "all men are mortal, Socrates is a man, so Socrates is mortal."  OR Steel is made in Hamilton. Knives are made of steel, so knives are made in Hamilton. These can be used to introduce the concept of valid logic, but the fact may be incorrect. Check with the mathematics program for additional sections on logic.	SISCON: How Can We Be Sure? "Why We Need to Know" and "Not So Sure" Science in Society: Nature of Science "The Nature of the Scientific Method"
2.0 Distinguish and describe differences among hypotheses, scientific laws and theories.	Use black boxes to re-introduce the concept of scientific models and their relationship to scientific theories. Limitations of models and theories can be developed.	Bassey, Science and Society "Scientific Method"

OBJECTIVE	NOTES TO TEACHERS
2.1 Relate the nature and limitations (uncertainties) of models to scientific theories.	 MODEL TRUTH Top of Black Box Teachers may wish to develop ideas about the limiting factors present in some of our standard measuring instruments which may affect the model or theory. This can lead into discussion on how theories change and are modified, e.g., atomic theory--consideration of the atom during Rutherford's time as based on the data available and modern atomic theory which must consider the Heisenberg Principle and thus, the atom becomes a model based on probability. Reasons for the former non-acceptance and present acceptance of Wegener's Continental Drift Theory can be discussed. Similarly, the phlogiston theory and the modern theory of combustion and the caloric theory (heat as a fluid) compared to the present kinetic molecular theory can be discussed from a scientific-historical perspective. For example, the discrepancy in the caloric theory (i.e., an object could only contain a fixed amount of heat) was not effective as a theory with new data obtained from Count Rumford's experiments in boring cannon. Science in Society: Nature of Science "How Science Develops" SISCON: How Can We Be Sure? "The Birth of Scientific Theories" Investigating the Earth "Crustal Plates: A Moving Sea Floor"

OBJECTIVE

2.2 Describe limitations in scientific laws.

NOTES TO TEACHERS

The limitations of Boyle's Laws can be illustrated using the following experimental results.

Pressure (atmospheres)	Volume (litres)	Pressure x Volume (atmosphere,litres)
0.10	10.0	1.0
0.50	2.0	1.0
1.0	1.0	1.0
5.0	0.20	1.0
10.0	0.10	1.0

The above experimental facts support the law. Suppose that we now improve our experimental technique so that pressure and volume can be measured more precisely. The following results may now be obtained.

Pressure (atmospheres)	Volume (litres)	Pressure x Volume (atmosphere,litres)
0.100	10.0	1.00
0.500	2.00	1.00
1.00	1.00	1.00
10.0	0.101	1.01

The last result might normally be considered to be a variation from the rule introduced by an inadequacy in our experimental procedure, rather than a failure in Boyle's Law.

The Ideas of Physics
"Heat"

Science in Society: Teacher's Guide
"What are the Facts?" and "Uncertainty and Belief"

OBJECTIVE	NOTES TO TEACHERS

Suppose that we again improve the experimental method and increase the pressure range. The following results might be obtained:

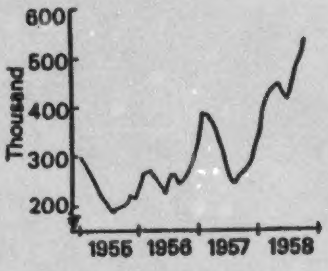
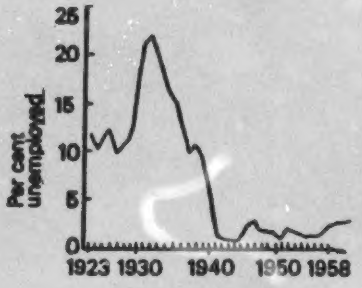
SISCON: How Can We Be Sure?
"Science Changes Its Mind"

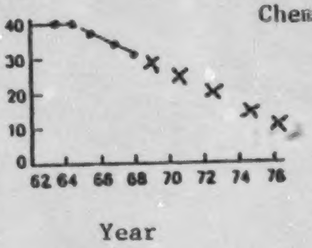
Pressure (atmospheres)	Volume (litres)	Pressure x Volume (atmosphere, litres)
0.1000	10.00	1.000
0.5000	2.000	1.000
1.000	1.000	1.000
5.000	0.2006	1.003
10.00	0.1006	1.006
50.00	0.02066	1.033
100.0	0.01064	1.064

These results are taken from some very accurate experiments with hydrogen. They show that Boyle's Law is an incorrect generalization and, therefore, following the procedure of scientific method, we should reject it. But to reject it is to overlook the point that in many calculations involving pressure and volume, the result is required only to a low order of accuracy, and only rarely are pressures used which are greater than a few atmospheres. (Source: Bassey, Science and Society: The Meaning and Importance of the Scientific Method.)

The limitations of a hypothesis or best approximation should be indicated at the same time. Although the hypothesis may not have universal application, its usefulness in making predictions can be indicated.

OBJECTIVE	NOTES TO TEACHERS	
EXTENSION ONE (Statistical Facts; Science, Invention and Social Interaction)		
1.0 Describe ways of presenting facts statistically and methods of presenting information in an incomplete or biased manner.		Bassey, Science and Society Science in Society: Teacher's Guide "What are Facts?"
1.1 Describe precision and reliability in statistical data and the effect of choosing different bases upon percentage.	This may be discussed in terms of using calculators to determine a value to a number of decimal places, but how reliable is the number? Conduct a survey to determine the number of slices of bread that the students ate the previous day and calculate the mean. This may be a precise number like 3.94 but how reliable is it if one student guesses incorrectly? Is this spurious precision? Examine the effect on percentage profit if it is worked out on cost price or selling price. Many examples of percentage growth in size, profits, etc., are available in newspaper reports.	How to Lie with Statistics
1.2 Describe the potential sources of bias in surveys and averages (median, mode, mean).	Conduct a survey to determine the amount of pocket money received by students from parents and determine median, mode and mean. Suggest ways in which the data could be used to argue for a raise. What are	

OBJECTIVE	NOTES TO TEACHERS
	potential sources of uncertainty in the data? Use other examples from Science and Society or How to Lie with Statistics to illustrate bias or uncertainty in sampling.
1.3 Describe how graphical data may be biased by using no or unspecified axes, changing axes and scales, changing origins, and pictographs or non-linear graphs.	Use the following graphs to introduce the concept that very different impressions can be made by using different scales or time periods but using the same data. UNEMPLOYMENT  POOR RECORD?  IMPROVEMENT?

OBJECTIVE	NOTES TO TEACHERS	
	Use sample graphs and data from Science in Society: Teacher's Guide or How to Lie with Statistics to illustrate the examples of biasing data. Additional sample questions are available in the mathematics program.	
1.4 Illustrate, with examples, the dangers of extrapolation.	Percentage Enrollment Chemistry  Have students gather examples of the use of statistics in advertising and have them evaluate the validity of the sources. Examination of some case studies from Bassey, Science and Society, about cigarette smoking and lung cancer, or the subject of dental caries and fluoridation could be examined in terms of the kinds of valid conclusions which might be obtained from the data.	Consider other examples of problems with extrapolation, e.g., for a period of time the number of T.V. sets in homes was increasing by 1,000 %, population projections, energy use projections. Refer back to core objective 2.2 in regard to extrapolation of data from Boyle's Law.

OBJECTIVE	NOTES TO TEACHERS	
2.0 Specify alternative definitions of risk (including a quantifiable definition), methods of determining risk (including strengths and weaknesses), the difference between risk, estimation and risk evaluation, and the concept of balancing risks against benefits.*	Activities are suggested in the teacher's guide to the film "How Safe is Enough?"	The film, "How Safe is Enough," is available from the Department of Education Library as is the teacher's guide for "On the Perception, Estimation and Evaluation of Risk"
3.0 Describe factors that affect the development of new ideas or inventions (creative factors, serendipity, intuition).	Have students read and report on articles and case studies from the references.	Science in Society: Nature of Science "Science and the Creative Imagination" and "Can Science tell the Whole Truth" SISCON: Technology, Invention and Industry "The Ingredients for Adventure," "Case Study of Plastics," and "Case Study of Microelectronics"
* This objective would require a number of hours to develop and could be deferred to the unit on energy alternatives.		

OBJECTIVE	NOTES TO TEACHERS
OPTIONAL OBJECTIVES (IF DESIRED)	
4.0 Relate the nature of science as a way of knowing to religion as a way of knowing.	Have students read and discuss "Religious Belief in a Scientific World" and "Science and Religion" from Science in Society: Nature of Science. The teacher may wish to bring in experts in this field.
5.0 Analyze a report using selected criteria.	A guide for analyzing reports is provided in Energy and Society: Investigations in Decision Making, "Analyzing and Interpreting Data." These materials are particularly aimed at helping students to examine reports about energy needs and alternatives.

OBJECTIVE	NOTES TO TEACHERS	
EXTENSION TWO (Development of Scientific Ideas: Societal Background)		
1.0 Describe the effect of the growth of technology upon ancient societies and the societal factors affecting the growth of science and technology.	Have students prepare short talks on some of the issues raised, e.g., the effect of slave labour on technological development, in Science and Social Development. Bring in a member of the social science department, who has had some classics to talk about Greek science and philosophy.	Science in Society: Science and Social Development (Book K) "Science, Technology and Society in the Ancient World"
1.1 Describe the versatility of Leonardo da Vinci and the reasons for the growth of knowledge during this period of time.	Conduct a short study of da Vinci	Science in Society: Science and Social Development (Book K) "From Darkness to Light"
1.2 Describe how new scientific ideas may develop conflict within a society.	Compare models of the universe (Ptolemaic vs. Copernican) in terms of why one may be more scientifically accurate than another. Examine the effects of the counter-reformation.	Science in Society: Science and Social Development (Book K) "From Darkness to Light" NOTE: This section may have been examined in "Motion of the Heavens" in Grade XI. Please check before developing this area.

OBJECTIVE	NOTES TO TEACHERS	
1.3 Specify how Newtonian ideas unified scientific thought and affected views of society.	Read "Newton and the Age of Reason" and "Francis Bacon and the Birth of Modern Science." Discuss the ideas presented in terms of their efforts and acceptance into modern times.	Science in Society: Science and Social Development (Book K) "Newton and the Age of Reason"

OPTION II: SOLAR ENERGY TIME: 15 Hours

RATIONALE: The increasing dependence of civilization on energy sources has motivated humankind to search for energy alternatives. One of the potential sources is solar energy.

This unit may be done independently as a Grade XI option on its own or it may be done as part of the energy alternative units in Grade XII. This unit is activity oriented and relies heavily on student activities and projects.

PRIMARY REFERENCES:

1. ALCHEM: Solar Energy--Solar Education for the 80's. Edmonton: J.M. LeBel Enterprises Ltd., 1980.

AND

2. ALCHEM: Solar Energy -- Solar Education for the 80's, Teacher's Guide. Edmonton: J.M. LeBel Enterprises Ltd., 1980.

3. Webb, Madelyn. The Canadian Environment: Data Book on Energy and Environmental Problems. Toronto: W.B. Saunders Company, 1980. (Single copy only required, available at the Department of Education Library.)

SUPPLEMENTARY REFERENCES:

1. McDaniels, David K. Solar Thermal Power. Stony Brook, NY: American Association of Physics Teachers. (Mimeo.)

*2. Ruedesili, Lon and Morris Firebaugh. Perspectives on Energy. Issues, Ideas and Environment Dilemmas, second edition. New York: Oxford University Press, 1978.

* Very useful teacher reference for many of the energy alternatives.

3. Articles from the Physics Teacher.
Ward, Dan S. "Advances in Solar Heating" and "Cooling Systems," April 1976, pp. 199-204.
Stimner, Arthur O. "A Solar House for Northern Latitudes," January 1978, pp. 25-30.
Leao, T. and R. Reese. "Student Investigations in Solar Heating Systems," May 1978, pp. 283-289.

4. Foster, H. and D. Sewell. Solar Home Heating in Canada: Problems and Prospects. Office of the Science Advisor, Department of Fisheries and Environment, Fontaine Building, Ottawa.

5. Energy Efficient Housing: A Prairie Approach. Winnipeg: Manitoba Energy, Mines and Resources, 1981.

6. Insulation in the Home: Energy Savings with Increased Insulation. Winnipeg: Manitoba Hydro, 1980.

OBJECTIVE	NOTES TO TEACHERS	
SOLAR ENERGY: HEATING The student should be able to:		
1.0 Describe solar energy relative to the electromagnetic spectrum and relate this to the major components reaching the earth's atmosphere.	Use a graph illustrating spectral distribution at upper atomosphere and relate to a diagram of the electromagnetic spectrum.	ALCHEM: Solar Energy "Energy Resources; Solar Radiation Reaching Earth's Atmosphere"
2.0 Describe heat losses and transfers.		ALCHEM: Solar Energy "Energy From the Sun Means Daily Solar for Each Month"
2.1 Describe, qualitatively the absorption reflection and transmission of solar energy in the Earth's atmosphere.	About 15% is absorbed by the atmosphere, 42% reflected by clouds, snow and water. Of the 43% absorbed by earth, about 40% is re-radiated or used to evaporate water.	Perspectives on Energy "Solar Energy"

OBJECTIVE	NOTES TO TEACHERS	
2.2 Relate variation in solar radiation to factors such as solar altitude or azimuth, direct and diffuse radiation and the tilt of the solar collector (Earth).	Use diagrams of solar altitude and azimuth to illustrate variation in pathlength at different times of the year and the effect during the day.	
2.3 Use the terms conduction, convection and radiation to explain heat transfer in the atmosphere and in buildings.		
2.4 Measure the relative intensity of solar radiation.	Use a radiometer and a stroboscope. The stroboscope can be used to measure the stop-speed, determine the frequency of the radiometer and the intensity of solar radiation.	
2.5 Describe the variation of the solar intensity on a daily, monthly and yearly basis.	Use solar energy data chart for a city nearest to the community and graph data.	
3.0 Describe ways in which entry of solar energy into a building can be controlled.	Discuss optimizing effective areas of windows, the effect of trees, other buildings, or projections on or outside the house.	ALCHEM: Solar Energy "Collecting Solar Energy: Colour of Solar Absorbers"

OBJECTIVE	NOTES TO TEACHERS	
3.1 Describe the importance and give examples of retrofitting.	Relate this to greenhouses and the greenhouse effect.	Energy in Perspective "Sources of Energy," and "Solar Energy" Perspectives on Energy "Solar Heating and Cooling"
3.2 Describe important characteristics of a low-energy dwelling.		
3.3 Define the greenhouse effect and thermal mass. Relate the characteristics of thermal mass to use in solar heat storage.		
3.4 Relate the role of thermosiphons to passive collection of solar energy. Observe and describe the function of a convection loop.	Use a glass convection loop heat source and food colouring to demonstrate the movement. Relate to K.E. - Molecular Theory.	
3.5 Describe ways in which loss of solar energy can be minimized. Make recommendations about approaches to and im-	Relate to insulation, decreasing air infiltration and window area.	Energy Efficient Housing: A Prairie Approach, "Insulation in the Home, Energy Savings with Increased Insulation"

OBJECTIVE	NOTES TO TEACHERS	
portance of conserving energy in homes.		"Passive Solar Gain"
3.6 Describe methods of increasing passive storage capacity.		
3.7 Compare the effectiveness of different colours upon solar radiation absorption.	Solar Panels: Use three to five small tin cans, the inside of each painted a different colour. Use squares of styrofoam for top (with hole same size as can) and bottom of cans. Place thermometers into the absorber panels which are placed perpendicular to the radiation.	
4.0 Compare thermal heat and latent heat of fusion. Calculate solar energy, stored as heat, using $h = vc\Delta t$, v=volume in m^3, c=heat capacity in megajoules per cubic metre degree Celsius and "h" is in megajoules.	Latent heat of fusion activity can be attempted. Provide students with relationships and data to solve problems.	ALCHEM: Solar Energy Lab 4, "Increasing Passive Collection and Storage Capacity: Solar Heat Storage"
4.1 Calculate the savings of certain solar energy applications and relate to present energy costs. Estimate potential future savings.		

OBJECTIVE	NOTES TO TEACHERS	
4.2 Compare the solar heat storage characteristics of different materials. Graph the results.	Use small tins (filled with different materials such as sand or wood chips), and heat in a solar oven. Transfer to milk cartons with thermometers and measure temperature changes over time.	
4.3 Compare the advantages and disadvantages of different methods of heat storage.		
5.0 Describe the characteristics and operation of active solar collectors and systems.	Discuss active air and liquid collectors.	ALCHEM: Solar Energy "Introduction to Active Systems: Concentrating Collectors" Physics Teacher "Advances in Solar Heating and Cooling Systems"
5.1 Discuss factors affecting the efficiency of active systems and compare active and passive systems reltative to practical and economic factors and advantages or disadvantages.		

OBJECTIVE	NOTES TO TEACHERS
5.2 Describe the characteristics and give examples of concentrating solar collectors and solar cells.	

OPTION III: FLUIDS AND HYDRAULIC DEVICES TIME: 10-15 Hours

RATIONALE: This unit is designed to help students understand another area upon which our present society is very dependent, that is, hydraulic power. The invention of many currently used hydraulic devices (based on fluid power) was a reaction to the technological needs of the time.

This area of study aids in showing the relationship between science and technology, promotes understanding of the development of skills used by scientists and promotes assimilation of scientific knowledge.

NOTE: This unit is based on Physics (Giancoli).

PRIMARY REFERENCES: 1. Giancoli, Douglas C. Physics. Englewood Cliffs, NJ: Prentice-Hall, 1980. (Teacher's reference.)

SUPPLEMENTARY REFERENCES:

1. Lubank, Howard L. et al. Physics for Secondary Schools. Toronto: Macmillan Company of Canada, 1959.
2. Barton, O.C. et al. Physics: The Fundamental Science. Toronto: Holt, Rinehart and Winston of Canada, 1967.
3. Tracy, G., H. Tropp, and A. Friedl. Modern Physical Science. New York: Holt, Rinehart and Winston, 1983.

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Calculate specific gravity of solids, liquids and gases from the concept of density.	Review density.	Giancoli, Physics 6.1, "Density and Specific Gravity"
2.0 Describe pressure in physical and mathematical terms.	Use kilopascals as a basic unit. Use numerical examples.	Giancoli, Physics 6.2, "Pressure and its Measurement"
2.1 Distinguish between force and pressure.	Use numerical examples to emphasize difference.	
2.2 Solve problems involving the parameters of pressure, force, area, specific gravity and height.	Do a dimensional analysis to affirm units of pressure (a good exercise). $P=F/A=pgh$.	
2.3 Demonstrate that pressure is independent of configuration of the container.	Show how bicycle tires and car tires can be used as examples. Demonstrate the similarity of trajectories of liquids emitted from a variety of "home-made" containers. NOTE: Ensure that openings and liquid levels are the same.	

OBJECTIVE	NOTES TO TEACHERS
2.4 Describe the nature of atmospheric pressure in qualitative and quantitative terms.	Use examples of barometric pressure and the effect of altitude on atmospheric pressure. Use SI units, e.g., pascals and kilopascals.
2.5 Distinguish between gauge pressure and absolute pressure.	Use tire pressure and altimeter variations.
3.0 Describe Pascal's Principle and demonstrate understanding with qualitative and quantitative illustrations.	Explain Pascal's Principle in terms of previously studied concepts of force and pressure in confined containers.
3.1 Identify practical examples of Pascal's Principle.	Demonstrate hydraulic devices such as: barometer, hydraulic jack, brakes (hydraulic and pneumatic), hoists, servomechanisms (aircraft flaps), robot movements, and blood pressure gauge. See Giancoli, Physics, for example, (pp. 154-155)
3.2 Calculate force input and force output using simple hydraulic piston arrangements.	Solve a wide range of hydraulic problems. An interesting class activity might be to have students measure their blood pressures and then discuss the physics of this measurement (may have been done by biology students).

OPTION IV: HEAT CONCEPTS AND HOME ENERGY CONSERVATION

TIME: 15-25 Hours

RATIONALE: An understanding of the nature of heat energy and its transfer from one area to another is important in examining ideas related to heat conservation.

With a good understanding of heat transfer, students will be able to find areas in their homes to increase heating efficiency and use these ideas to improve efficiency when considering purchasing homes of their own in this cold winter area of our country.

PRIMARY REFERENCES:

1. Williams, John E. et al. Modern Physics. Toronto: Holt, Rinehart and Winston of Canada, 1984.

AND

2. Keeping the Heat In. Ottawa: Energy, Mines and Resources, Canada, 1980.

SUPPLEMENTARY REFERENCES:

1. Giancoli, Douglas C. Physics. Englewood Cliffs, NJ: Prentice-Hall, 1980.
2. Paul, Douglas et al. Physics, A Human Endeavour: Unit 3, Energy and the Conservation Laws. Toronto: Holt, Rinehart and Winston of Canada, 1976.
3. 100 Ways of Saving Energy and Money in the Home. Ottawa: Energy, Mines and Resources, Canada, 1979.
4. Energy Management for the Future. Ottawa: Energy, Mines and Resources, Canada, 1979.
5. Insulation: Efficient Use of Electricity. Winnipeg: Manitoba Hydro, 1980.
6. Electric Heat in the Home: The Efficient Use of Electricity. Winnipeg: Manitoba Hydro, 1980.

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Define heat as a form of energy.	Have the students describe how heat is converted to mechanical energy as in an internal combustion engine and turbines.	Giancoli, Physics 7, "Temperature and Kinetic Theory"
1.1 List different forms of heat such as sun, friction, electrical.		
2.0 Define heat units.		
2.1 State the relationship between joules and calories.	Determine the relationship of calories to joules and determine the number of joules produced from burning a candle or melted wax.	Modern Physics 9.1, "Mechanical Equivalent of Heat"
2.2 Measure and define heat exchange.	Do an experiment on heat exchange.	Modern Physics 8.13, "Law of Heat Exchange" Modern Physics: Laboratory Experiments in Physics Experiment 20, "Heat of Fusion" Experiment 21, "Heat of Vaporization" Experiment 22, "Mechanical Equivalent of Heat"
2.3 Measure and define heat capacity.		Modern Physics, 5th ed., 8.11, "Heat Capacity"

OBJECTIVE	NOTES TO TEACHERS	
2.4 Experimentally determine the specific heat of water and one or two other substances, e.g., aluminum, brass.	Information dealing with heat transfer and its relationship to kinetic energy molecules theory is necessary for background.	Modern Physics: Laboratory Experiments in Physics Experiment 19, "Specific Heat" Modern Physics 8.12, "Specific Heat" Giancoli, Physics 9.4, "Keeping the Heat In"
3.0 Describe factors affecting heat transfer. 3.1 Describe the three factors (material, thickness, temperature difference) which affects conduction. 3.2 Decribe the factors affecting convection (cellular construction, geometrical control, loss of warmest material).		

OBJECTIVE	NOTES TO TEACHERS	
3.3 Describe the factors affecting radiation loss (difference between absolute temperature to fourth power).		
4.0 To keep the heat in his/her home and the cold out (old homes or new).		Giancoli, Physics 9.4, "Heat Transfer"
4.1 Know the meaning and advantages of retrofitting in relation to money, comfort, energy.	Students should watch the film series, "Home Insulation" (VHS or Beta). This series is available from the Department of Education.	Keeping the Heat In
4.2 Know the basics of how a home is built, e.g., foundation, structure, cellar, windows and doors, ceiling and roof.		Giancoli, Physics 9.4, "Heat Transfer"
4.3 Relate home insulation factors such as R values, vapour barrier, floors, doors, windows, ceilings to conservation of heat.		Energy Management for the Future Energy Efficient Housing: A Prairie Approach Insulation: Efficient Use of Energy

OPTION V: MOTION: EARTH AND SKY TIME: 20 Hours

RATIONALE: Using astronomy, the oldest branch of physics, this unit relates the interaction between the development of new scientific theories and the society within which science operates. The nature of science, as based upon the powers of observation, certain values and a means for evaluating and accepting or rejecting new ideas, is developed in this unit. In addition, this unit illustrates the relationship between mathematics and science and supports the development of some simple processes by providing a variety of activities.

PRIMARY REFERENCES:

AND/OR

1. Paul, Douglas et al. Physics, A Human Endeavour: Unit 2, Motion in the Heavens. Toronto: Holt, Rinehart and Winston of Canada, 1976.
2. Haber-Schaim, Uri et al. PSSC Physics, 5th edition. Toronto: D.C. Heath and Company, 1981.
3. Haber-Schaim, Uri et al. PSSC Physics, 4th edition. Toronto: D.C. Heath and Company, 1976.

SUPPLEMENTARY REFERENCES:

1. Wenham, E.J. Longman Physics Topics: Planetary Astronomy. London: Longman Group Ltd., 1970.
2. Holton, G. et al. Project Physics. Toronto: Holt, Rinehart and Winston, 1981.
3. Holton, G. et al. Project Physics Handbook. Toronto: Holt, Rinehart and Winston, 1981.
4. Brecht, Berthold. The Life of Galileo. London: Methuen, 1968.
5. Wilson, Curtis. "How Did Kepler Discover His First Two Laws?" Scientific American, March 1972.
6. Bauman, R.P. and T.J. Wdomiak. "Cosmological Models." The Physics Teacher, Vol. 18, No. 9, December 1980.
7. Santon, J. "Measuring the Moon's Orbit." The Physics Teacher, Vol. 18, No. 17, October 1980.

*8. Lewis, John L. (editor). Science in Society: Nature of Science (Book J). Heinemann Educational Books Ltd., 1981.

9. Seeger, Raymond F. "Galileo Galilei: Outline of his Life and his Works," The Physics Teacher, Vol. 4, No. 4, April 1966.

TEACHER REFERENCES:

1. Giancoli, Douglas C. Physics. Englewood Cliffs, NJ: Prentice-Hall Inc., 1980.

2. Drake, Stillman. Discoveries and Opinions of Galileo. Gordon City, NY: Doubleday, 1957.

3. Joravsky, D. The Lysenko Affair. Harvard University Press, 1970.

4. Kaufmann, William J. III. Exploration of the Solar System. New York: Macmillan Publishing Company, Inc., 1978.

5. Philips Planisphere, star map available from the Manitoba Museum of Man and Nature.

6. The Observer's Handbook. Toronto: Royal Astronomical Society of Canada.

7. Dickinson, Terence. Nightwatch: An Equinox Guide to Viewing the Universe. Camden East, ON: Camden House Publishing Ltd., 1983.

AUDIO-VISUAL:

1. Cosmos Series (available from the Department of Education Library).
   Episode 1: "The Shores of the Cosmic Ocean"
   Episode 3: "Harmony of the Worlds"
   Episode 4: "Heaven and Hell"
   Episode 5: "Blues for a Red Planet"
   Episode 8: "Journeys in Space and Time"
   Episode 10: "The Edge of Forever"
   Other episodes are available.

2. Programs are available at the Manitoba Planetarium.

* Useful in examining science-societal interactions. Since this can be used in developing the unit, Facts, schools should decide the best place for using this material if it is chosen.

OBJECTIVE	NOTES TO TEACHERS	
PART 1 Motion: Heavenly Objects* * Check with students initially in case they have studied some of the ideas at an earlier time. The student should be able to:		
1.0 Identify major constellations on a star chart or stellar globe. 1.1 Provide the names and positions of the major planets visible at the time of this option.	Relate naked-eye observations of Polaris (measuring azimuth and altitude) to the other bright stars. Note daily motion. Locate some major constellations. Relate observations to star chart or stellar globe.	Physics, A Human Endeavour: Motion in the Heavens Experiment 6.1, "Naked Eye Observation" Chapter 6.1 to 6.2 The Observer's Handbook Philips Planisphere
1.2 Describe the regularities in the motions of the sun, moon, stars and planets. 1.3 Graph planetary motion for Mercury and Mars relative to the sun. 1.4 Plot the path of the sun, using a gnomon.	Obtain data about the motion of the sun for one day by using a gnomon and astrolobe. CAUTION: NEVER LOOK DIRECTLY AT THE SUN. Obtain monthly data for the motion of the moon.	Physics, A Human Endeavour: Motion in the Heavens Experiment 6.2, "Motion of the Sun" Experiment 6.3, "The Celestial Sphere-Equator Coordinate System" Experiment 6.4, "Motions of the Moon" Experiment 6.5, "The Planets"

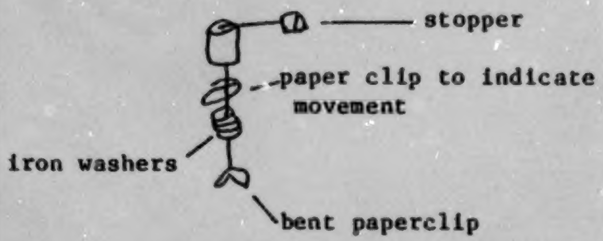
OBJECTIVE	NOTES TO TEACHERS	
		Project Physics Handbook Experiment 2.7, "Using Lenses to Make a Telescope"
1.5 Construct a sundial, an astrolobe and a celestial globe.	Build a permanent sundial. Consult Manitoba Planetarium for sources of plans.	
Models of the Universe		
2.0 Compare Greek models of the universe (e.g., Plato's and Eudoxus' models).	Examine the assumptions upon which celestial objects were believed to move in Grecian times, e.g., uniform speed and their relationship to observations of objects and knowledge at that time.	Physics, A Human Endeavour: Motion in the Heavens 6.6, "The Statement of the Problem" 6.7, "The Early Greek View of the Universe"
2.1 Defend the Greeks' geocentric model of the universe as being most useful and appropriate to their time. Relate this to the nature of scientific truth at that time.		
2.2 Define retrograde motion relative to planetary motion.	This concept can be introduced by means of pictures, a diagram or a film loop.	PSSC Physics, 5th ed. 5.7, "From the Greeks to Kepler: A Brief Historical Sketch"

OBJECTIVE	NOTES TO TEACHERS	
		Physics, A Human Endeavour: Motion in the Heavens 6.8, "The Models of Ptolemy"
2.3 Describe the successes and limitations of the Ptolemaic model of the universe.	Construct models of Platonic solids and describe how they were used to attempt to explain planetary motion. Relate the use of an eccentric or epicycle to observations and the model.	Physics, A Human Endeavour: Motion in the Heavens 6.9, "Successes and Limitations of the Ptolemaic Model"
Does the Earth Move? Copernicus		Project Physics "Where is the Earth? The Greeks Answer"
3.0 From data on the sun's position in the sky, construct the orbit of the earth.	Discuss frames of references in simple situations such as being a passenger on a moving train or on a boat crossing a river.	PSSC Physics, 5th ed. 5, "Gravitations on the Large Scale"
3.1 Construct a Foucault pendulum and relate its action to a rotating earth.	Relate this to the shift in thinking necessary to move from an earth-centred to a sun-centred system. Discuss the scientific reasons for the greater acceptability of the Copernican over the Ptolemaic mode.	Physics, A Human Endeavour: Motion in the Heavens Experiment 7.1, "The Shape of the Earth's Orbit"

OBJECTIVE	NOTES TO TEACHERS	
3.2 Describe the strengths and weaknesses of the Copernican model of the universe.		Activity 7.1, "Finding Orbit Radii" Activity 7.2, "Scale Model for the Solar System" Activity 7.3, "Frames of Reference" Activity 7.4, "Foucault Pendelum" Project Physics "Does the Earth Move? The Work of Copernicus and Tycho"
Observations and Models: Kepler and Galileo		
4.0 From data, construct the orbit of Mars or Mercury.	Photographs showing Mars among the stars are used to determine coordinates of Mars and the orbit.	Project Physics "A New Universe Appears: The Work of Kepler and Galileo"
4.1 State and describe the development of Kepler's Law of Periods.	Kepler's Laws can be related to data available in the materials.	Physics, A Human Endeavour: Motion in the Heavens Experiment 8.1, "The Ellipse"

OBJECTIVE	NOTES TO TEACHERS	
4.2 Apply Kepler's Law of Periods to data from other planets such as Jupiter.		
4.3 Describe how evidence about the sun and moon developed by Galileo via telescope weakened the earth-centred view of the universe.	The Aristotelian view of the universe, i.e, the universe was perfect in all characteristics, was affected by observations of the uneven surface of the moon. In addition, evidence from the revolution of the four moons of Jupiter affected the usefulness of the earth-centred model. Most of Galileo's observations can be repeated with seven-power binoculars, mounted on a tripod.	Experiment 8.2, "Mars' Orbit" Experiment 8.3, "Orbit of Mercury" Experiment 8.4, "Inclination of Mars' Orbit" Booklet of photographs is required. PSSC Physics, 5th ed. 5, "Gravitations on the Large Scale"
4.4 Describe how the scientific evidence of the sun-centred model conflicted with other beliefs.	Compare how the different beliefs may interact, and how they can be reconciled on the basis of acceptance of different assumptions.	Physics, A Human Endeavour: Motion in the Heavens 8, "A New Universe Appears: The Work of Kepler and Galileo"

OBJECTIVE	NOTES TO TEACHERS
	Galileo Physics Teacher "Galileo Galilei: An Outline of His Life" Science in Society: Nature of Science (Book J) "Can Science Tell the Whole Truth?"
PART II Gravitation: Newton to Einstein 5.0 Describe how the force of gravity can be responsible for the laws of motion for falling bodies and heavenly bodies.	Physics, A Human Endeavour: Motion in the Heavens 9.2, "What Makes the Planets Go Around"" 9.3, "The Law of Universal Gravitation" 9.4, "Determination of the Constant G" PSSC Physics, 5th ed. Chapter 5, "Gravitation on the Large Scale"

OBJECTIVE	NOTES TO TEACHERS	
5.1 Describe and apply the concept of centrifugal force to planetary orbits.	Data may be obtained by using the following apparatus. CAUTION: Refer to lab guide before introducing the activity.	Physics, A Human Endeavour: Motion in the Heavens Experiment 9.1, "Centripetal Force" Experiment 9.2, "Stepwise Approximation to an Orbit"
5.2 Describe the differend kinds of orbits possible based on gravitational force laws and provide examples from heavenly bodies.	 stopper paper clip to indicate movement iron washers bent paperclip	Project Physics "The Unity of Earth and Sky: The Work of Newton" PSSC Physics, 5th ed. 5, "Gravitation on the Large Scale"
5.3 Describe how application of the Law of Universal Gravitation helped to predict the presence and location of heavenly bodies.	Neptune was discovered on the basis that observation of the orbits and positions of known planets did not fit predictions from the Law of Universal Gravitation.	Physics, A Human Endeavour: Motion in the Heavens 9.5, "Dividends from the Law of Gravity" 9.6, "The Discovery of Neptune" Activity 9.3, "Building a Cavendish Apparatus"

OBJECTIVE	NOTES TO TEACHERS	
5.4 Describe how Cavendish weighed Earth.	The Cavendish experiment can be done as a classroom demonstration.	PSSC Physics, 5th ed. 5.6, "Laboratory Tests of the Law of Gravitation"
5.5 Compare Newtonian concepts of gravity to modern concepts of gravity and the universe. Relate this to modern views of the nature of the universe.	Relate Newton's ideas to Hubble's observations relative to the universe. Discuss the "cosmological principle." Is it strictly valid in the light of current knowledge? Can we know?	Physics, A Human Endeavour: Motion in the Heavens Epilogue, "A Modern View of the Universe"

physics 300 (core)

UNIT 1: WAVES TIME: 10 Hours

RATIONALE: The study of waves and wave mechanisms is integral to the further investigation of a number of topics in physics. Topics which can be developed are: optics, sound, energy transmission, alternating current, electronics and atomic physics. The purpose of the unit is to expose the student to some basic ideas related to waves to enhance their transition into the above topics. The position of this core unit within the course is dependent upon the type of choice of the physics-technology-societal unit.

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Describe waves in terms of transmission of energy.	Use springs or the slinky to demonstrate differences between the waves. Solve problems involving frequency, wave length and velocity.	Modern Physics, Chapter 10
2.0 Distinguish between longitudinal and transverse wave systems.	Two laboratory activities on waves are recommended.	PSSC Physics, 5th ed. Chapter 22
3.0 Physically describe waves in terms of amplitude, frequency, wave length and velocity.		Modern Physics: Laboratory Experiments in Physics "Pulses on a Coil Spring" PSSC Physics Laboratory Guide, 5th ed. "Waves in a Coil Spring"
4.0 Derive the relationship $V=f\lambda$.	The relationship can be obtained by experimenting with a resonant column.	Modern Physics: Laboratory Experiments in Physics, "Resonance: The Speed of Sound" PSSC Physics Laboratory Guide, 5th ed. "Pulses in a Ripple Tank"

OBJECTIVE	NOTES TO TEACHERS	
5.0 Observe and describe the following wave properties: a) rectilinear propagation b) reflection c) refraction d) diffraction e) impedance f) interference	Perform ripple tank experiments to demonstrate the wave properties of diffraction, interference and others. Do not employ Snell's Law; this can be developed in the optics unit if it is chosen as an option.	Modern Physics: Laboratory Experiments in Physics "Wave Properties" (omit Snell's Law) PSSC Physics Laboratory Guide, 5th ed. "Refraction of Waves" (omit Snell's Law) "Waves and Obstacles"
6.0 Relate interference phenomena to: a) superposition of waves b) standing waves	Superposition and standing waves can be developed by demonstrating with a slinky or by using ripple tanks.	PSSC Physics Laboratory Guide, 5th ed. "Interference and Phase"
7.0 Apply wave phenomena to some aspects of sound and light such as Doppler effect and resonance.		

UNIT 2: STATIC ELECTRICITY

TIME: 5 Hours

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Define the concept of charge in terms of conservation of charge.	Explain the structure of the atom in terms of excess or deficiency of electrons in an atom or groups of atoms.	Modern Physics 16.1 to 16.7
2.0 Differentiate between insulators (non-conductors) and conductors in terms of the mobility of electrons.	Experiment with attraction and repulsion employing electroscopes. Explain the results in terms of charge mobility. Laboratory experiments in Physics should be done at the beginning of this section to illustrate several properties of electric charges. Charge by contact and induction can be demonstrated and explained. A laboratory activity on electrostatics is recommended.	PSSC Physics, 5th ed. 10.1 to 10.4 and 10.7 to 10.8 PSSC Physics Laboratory Guide, 5th ed. "Electrified Objects," "Electrostatic Induction" Modern Physics: Laboratory Experiments in Physics "Electrostatics" Film: "Electrostatics" Available from the Department of Education
3.0 Demonstrate like charge repulsion and unlike charge attraction. . Charge by contact and induction.		
4.0 Explain charging by contact in terms of static electrical theory.		
4.1 Explain charging by induction in terms of static electrical theory.		
4.2 Explain "grounding" as applied to charging and discharging.		

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Sketch the force field about a charged body.	View the film entitled "Electric Lines of Force." If available, electric lines of force can be sketched by using the field mapping kit (this is available from Merlin Scientific).	Modern Physics 16.8 to 16.10, 16.14 to 16.16 PSSC Physics, 5th ed. 11.1 to 11.3 Film: "Electric Lines of Force" available from Department of Education Library
2.0 Demonstrate the existence of fundamental units of charge.	Perform the Milliken experiment or view the PSSC film about Milliken's experiment. Perform an experiment to obtain the $F \alpha 1/r^2$ function. For example, the soda straw activity can be used to develop this idea.	"Soda Straw Balance Experiment" is found in Electricity and Magnetism Activities, Manitoba Department of Education
3.0 Measure the force between charges. a) Define the quantity of charge as a coulomb. One coulomb is equal to 6.25 x 10^{18} elementary charges.	View the film entitled "Coulomb's Force Constant." A laboratory activity on Coulomb's Law is recommended.	
4.0 Describe how capacitors store an electrical charge.	Demonstrate the operation of a Leyden jar. CAUTION: Do not use electrostatic equipment for charging jar generators, e.g., Van de Graff.	

OBJECTIVE	NOTES TO TEACHERS	
4.1 Define dielectric materials.		
5.0 Describe the motion of charges between charged plates.		Modern Physics 16.10
5.1 Quantitatively analyze the energy changes that occur when a charged particle is accelerated between two charged, parallel plates.	To analyze the energy changes, use provided data in "Time of Flight" experiments with charges. As further examples, cathode ray tubes such as computer monitors or T.V. sets can be used for discussion purposes.	PSSC Physics, 5th ed. 12.4 to 12.5 and 12.8 See Electricity and Magnetism Activities Manitoba Department of Education
5.2 Relate the potential energy of the source to the energy gained by the charge.	Solve problems using: $W = qV$ and $q = IT$ NOTE: Students should be aware that the work done on a charge is independent of the medium, through which the charge is transported and depends only on the source of energy, e.g., across a vacuum, through solutions or wires.	Films: "Electrical Potential Energy and Potential Difference" "E.M.F." Available from the Department of Education Library

OBJECTIVE	NOTES TO TEACHERS
6.0 Define volts in terms of joules and coulombs.	Solve problems using Power = volts x amperes.
7.0 Define ampere as the number of coulombs moving past a point in a conductor in one second.	
8.0 Calculate the work done in moving charges.	
9.0 Define power as work done per unit time on moving charges.	

UNIT 4: BASIC ELECTRICAL CIRCUITS

TIME: 20 Hours

OBJECTIVE	NOTES TO TEACHERS
The student should be able to:	
1.0 Develop Ohm's Law from data. 1.1 State that resistance is a property of the circuit element. Define the ohm.	Perform experiments with a series circuit (graph V vs. I with a fixed resistance). Slope of the line equals resistance. NOTE: Students should be introduced to safety and the use of meters early in this unit (previous to any measurement). Modern Physics 17.1 to 17.13 PSSC Physics, 5th ed. 16.1, 16.2, 16.7, 16.9
2.0 Describe sources and characteristics of electrical energy (e.m.f.), for example, that they: . produce a fairly constant difference of potential . have polarity (+, -) . cause flow of current when a circuit is completed.	Experiment with simple series circuits employing voltmeters and ammeters. Calculate the work done in moving charges. Solve problems using work = volts x coulombs; power = volts x amps. Three laboratory activities on Ohm's Law and circuitry are suggested.
2.1 Infer that the amount of the current is determined by the voltage of the source and the resistance of the elements of the circuit.	
2.2 Describe types of sources of e.m.f. (different types of cells, generators, photocells).	

OBJECTIVE	NOTES TO TEACHERS
3.0 Describe the characteristics of a simple series circuit: . uniformity of current . individual voltage drops add to total potential difference applied to circuit. 3.1 Compute total resistance in a series circuit. 3.2 State that the sum of the resistors equals total resistance of the circuit and apply the relationship: $R_t = R_1 + R_2 + R_3 + \ldots R_n$. 3.3 State and apply the concept that resistances in series operate as voltage divi-	Perform an experiment using multi-element circuits.

OBJECTIVE	NOTES TO TEACHERS	
ders in direct proportion with the resistance.		
3.4 Compute the total power developed in a series circuit.		
3.5 Demonstrate that the sum of the power developed by the individual elements in a circuit equals total power developed by the circuit. Apply this concept.		Modern Physics: Laboratory Experiments in Physics "Measurement of Resistance: Voltmeter-Ammeter Method," "Resistances in Series and Parallel" and "Simple Networks"
4.0 Compute the current in the branches of a parallel circuit.	Perform experiments using a multi-branch parallel circuit.	Films: "Pressure and Current" "Electrical Potential Energy and Potential Difference" Available from the Department of Education Library
4.1 Infer that the sum of the current in the individual branches adds up to the circuit current.		See Electricity and Magnetism Activities, Manitoba Department of Education
4.2 Describe that a parallel branch serves as a current divider in an inverse proportion to the resistance.		

OBJECTIVE	NOTES TO TEACHERS	
4.3 Compute the voltage drops in a parallel circuit.		
4.4 Demonstrate that the voltage drop across each member of a parallel group is the same.		
4.5 Compute the total resistance of a parallel group.		
4.6 Derive the relationship: $\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \dots \frac{1}{R_n}$		
4.7 Infer that the combined resistance of a parallel group is less than that of the smallest resistor in the group.		
4.8 Calculate the current and voltage drop for any portion of a compound circuit (series and compound).	Perform experiments employing a compound circuit.	Modern Physics: Laboratory Experiments in Physics "Simple Networks"

OBJECTIVE	NOTES TO TEACHERS
4.9 Compute the total power developed by a compound circuit.	
4.10 Calculate the power generated by individual elements in a compound circuit and the total power developed by the individual elements.	Modern Physics: Laboratory Experiments in Physics "Resistance in Series and Parallel," "Measurement of Resistance: Wheatstone Bridge Method" (can be done if wheatstone Bridges are available)
4.11 Infer that the sum of the power developed by the individual elements equals the power developed by the total circuit: $P_t = P_1 + P_2 \; . \; . \; . + P_n.$	For more information, refer to "DC Circuits" in Giancoli, Physics Modern Physics 18.1 to 18.5 Physics, A Human Endeavour: Electricity
5.0 Describe the factors affecting the resistance of a uniform conductor.	Perform experiments measuring change in resistance with changes in length, cross-sectional area and material.
5.1 Infer the relationship between resistance of a conductor and length, cross-sectional area and kind of material.	

OBJECTIVE	NOTES TO TEACHERS
6.0 Apply the principles to practical problems involving various kinds of circuits.	NOTE: In practical laboratory situations, the internal resistance of the energy supply must be considered. If not done in a Grade XI option, perform experiments relating heat output to electrical energy input. Provide students with heat equations. The formulae $W = I^2RT$ and $W = VIT$ can be applied. Other examples are the work which can be done by an electrical motor which lifts weights.

UNIT 5: BASIC MAGNETISM TIME: 15 Hours

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Sketch a magnetic field around a current-carrying conductor, a permanent magnet, and a solenoid.	Perform experiments to map out the magnetic field, e.g., use a bar magnet and iron filings. Perform an activity to show the direction of a field in a current-carrying loop. NOTE: Right- or left-hand rule may be used, depending upon references.	Modern Physics 19.1 to 19.6 and 19.8 to 19.11 PSSC Physics, 5th ed. 14.1 to 14.4 and 14.6 and 14.7
1.1 Demonstrate the rule for direction of a field around a current-carrying conductor.		
2.0 Develop the formulae for a magnetic field around a straight wire, in the centre of a loop and in the centre of a solenoid.	Solve problems using the formulae $B_{\perp}IL$ and $qVB_{\perp}$. A laboratory activity on magnetic field lines and/or a solenoid is recommended.	Atomic Physics "Thomson" - a computer program dealing with determining the charge to mass ratio of an electron is available for the Apple computer only. Available from Programs for Learning, New Milford, Connecticut.
2.1 Perform sample calculations to find the strength of a field: . calculate the force on a moving charge . derive $F = qVB_{\perp}(VIB_{\perp})$. derive $F = B_{\perp}IL$		

OBJECTIVE	NOTES TO TEACHERS	
3.0 Measure the force of a magnetic field on a current-carrying conductor.	Perform experiments to measure the magnetic field in a solenoid and the mass of an electron. The film "The Mass of an Electron" may be viewed to summarize the ideas. NOTE: PSSC Physics Laboratory Guide, 5th edition, is useful here.	PSSC Physics Laboratory Guide, 5th ed. "Magnetic Field of a Current," "The Measurement of a Field in Fundamental Units," and "The Magnetic Field Near a Long Straight Wire"
3.1 Employing rules, predict the direction of the force.		Modern Physics: Laboratory Experiment in Physics "Magnetic Field about a Conductor"
3.2 Calculate the force on a current-carrying conductor.		
4.0 Compute the force between two straight current-carrying conductors.	Solve problems involving fields and conductors.	
4.1 Define the ampere in terms of force between two parallel current-carrying conductors.		

UNIT 6: ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT TIME: 20 Hours

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 State the causes of induced currents.		Modern Physics 20.1 to 20.6
2.0 Describe and define magnetic flux as $\phi = B A$.		PSSC Physics, 5th ed. 15.1 to 15.6
3.0 State Faraday's laws and relate the laws to practical examples. $E = \frac{\Delta\phi}{\Delta t}$ and $E = \frac{N\Delta\phi}{\Delta t}$	Perform experiments using galvanometers, coils and bar magnets. NOTE: Different textbooks use different symbols for electrical energy, e.g., E, V, I.	Film: "Electrical Lines of Force" Available from Manitoba Department of Education Modern Physics: Laboratory Experiments in Physics "Electromagnetic Induction"
3.1 Calculate the strength of induced e.m.f.		
4.0 Define Lenz's Law and apply the law to predict direction of induced e.m.f.	Demonstrate induction coils and their function. CAUTION: Use automotive coil and spark plugs. See ISIS: Know Your Car for additional information. High voltage spark discharges are potential sources of x-rays. See Safety in Science for spark gap voltages. A laboratory activity on induction and/or motors and generators is recommended.	Film: "The Generator and the Motor" available from Manitoba Hydro Inductance demonstrations are found in Electricity and Magnetism Activities, available from Manitoba Department of Education.

OBJECTIVE	NOTES TO TEACHERS	
5.0 Describe how current is induced in a rectangular armature in a uniform magnetic field.	Experiment with loops in a uniform magnetic field.	Modern Physics 20.7 to 20.10, 20.14, 20.15, 20.18, 20.19, 20.21, 21.1
6.0 Describe the AC cycle.	Demonstrate simple generators.	Impedance in AC is found in Electricity and Magnetism Activities, Manitoba Department of Education
6.1 Describe the operation of a commutator.		
7.0 For alternating currents, compute effective current and voltage.	Transformers are to be discussed in core and they are not present in the PSSC text. Modern Physics can be used for this discussion to understand the transformers. Construct simple transformers to operate at low AC voltage. Power input = power output, output depends on input, output turns ratio. Explain how the flux changes cause the output. Much of the core material on electricity and magnetism from PSSC will have to be supplemented by Modern Physics or Physics by Giancoli, or Physics, A Human Endeavour: Book 5, Electricity.	
7.1 Define effective values of amperes and volts.		
7.2 Describe, qualitatively, the effect of impedence on Ohm's Law in AC.		
8.0 Describe the operation of AC motors.	Perform experiment with motors and generators.	
8.1 Describe, qualitatively, the production of back e.m.f. in motors.		

OBJECTIVE	NOTES TO TEACHERS
8.2 Explain, qualitatively, the motor effect of generators.	
8.3 Observe the generator and motor effects in a generator.	
9.0 Describe the operation of transformers in terms of: . power input = power output . power depends on output . output turns ratio $\frac{Vs}{Vp} = \frac{Ns}{Np}$	Construct simple transformers to operate at a low AC voltage. NOTE: Refer to Safety in Science.
9.1 Describe how the flux changes in transformers cause the output.	

physics 300 (options)

OPTION I: SOUND TIME: 20 Hours

RATIONALE: Sound is part of most aspects of our lives. For example, we communicate with other people by means of speech, and we enjoy listening to music. Some animals communicate by using sound in quite unique ways. For instance, whales can send sounds over distances of hundreds of kilometres. Bats use sound waves to guide them in their flights. Human beings have developed special sonar techniques to measure the depth of the ocean and for some kinds of medical diagnosis.

The last part of this unit consists of two sections. Section I treats the production and control of noise in industry and the environment as one of the concerns of modern society. Section II deals with music and musical instruments.

PRIMARY REFERENCES:

1. Paul, Douglas et al. Physics, A Human Endeavour: Unit 4, The Nature of Light and Sound. Toronto: Holt, Rinehart and Winston of Canada, 1976.

OR

2. Williams, John E. et al. Modern Physics. Toronto: Holt, Rinehart and Winston of Canada, 1984.

TEACHER REFERENCES:

1. Giancoli, Douglas C. Physics. Englewood Cliffs, NJ: Prentice-Hall, 1980.
2. Holton, G. et al. Project Physics. Toronto: Holt, Rinehart and Winston of Canada, 1980.

SUPPLEMENTARY REFERENCES:

1. Williams, John E. et al. Exercises and Experiments in Physics. Toronto: Holt, Rinehart and Winston, 1972.
2. Stevens, S. et al. Sound and Hearing. New York: Life Science Library, Time-Life Books, 1970.
3. Laundry, George et al. Physics: An Energy Introduction. Toronto: McGraw-Hill Ryerson Ltd., 1979.
4. Dittman, Richard et al. Physics in Everyday Life. Toronto: McGraw-Hill Ryerson Ltd., 1979.
5. Stollberg, Robert et al. Physics: Fundamentals and Frontiers. Boston: Houghton Mifflin, 1980.

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OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Describe the relationship between sound and vibration.	Demonstrate with tuning forks or vibrating strings, etc.	Modern Physics 2.1, "Sonic Spectrum" 2.2, "Production of Sound" 2.3, "Sound Transmission"
2.0 Explain sound in terms of waves.	View the PSSC, 5th ed. film "Sound Waves in Air."	Giancoli, Physics 2.5, "Wave Motion"
2.1 Apply the wave formula $\lambda=v/f$.	Solve problems using wavelength, velocity, and frequency.	
2.2 Distinguish among three aspects of any sound, i.e., sound, wave transmission, detectors.		
2.3 Explain how sounds are reflected from surfaces, echoes, reverberations, absorption.	Perform experiments on characteristics of sound.	Physics, A Human Endeavour: The Nature of Light and Sound Experiment 14.1, "Behaviour of Sound"
2.4 Define and differentiate between ultrasonic and infrasonic.		

OBJECTIVE	NOTES TO TEACHERS	
2.5 Describe applications of ultrasonic and infransonic sound		Giancoli, Physics 12.8, "Acoustical and Medical Applications of Sound and Ultrasound"
3.0 Describe the factors affecting sound transmission.	Perform an experiment on the speed of sound.	Physics, A Human Endeavour: The Nature of Light and Sound Experiment 14.2, "Speed of Sound"
3.1 Compute the speed of sound in air at various temperatures.	The velocity of sound in air is: $v=331.5m/s + .6m/s(^\circ C)$. Use the above relationship to predict the speed at various temperatures.	Modern Physics 11.4, "Speed of Sound"
3.2 Compare the speed of sound in two other mediums to speed in air.		
3.3 Describe the Doppler Effect.		
3.4 Calculate the effective frequency of sound as affected in the Doppler Effect.	Demonstrate, using moving sound sources, i.e., cars. Solve problems by demonstrating the Doppler Effect.	Physics, A Human Endeavour: The Nature of Light and Sound 14.9, "Doppler Effect and Sonic Booms"

OBJECTIVE	NOTES TO TEACHERS	
		Modern Physics 11.9, "Doppler Effect"
3.5 Explain the creation of a sonic boom.		Giancoli, Physics 12.9, "Doppler Effect." 12.10, "Shock Waves and the Sonic Boom"
Section I: Noise		
4.0 Describe the operation of the human ear.	Suitable diagrams are available in The Nature of Light and Sound.	Physics, A Human Endeavour: The Nature of Light and Sound 14.4, "The Human Ear"
5.0 Define presbycusis, i.e., hearing loss specifically attributed to aging effects or occupational noise.	Contact Work Place Health and Safety, Manitoba Department of Labour for standards and measurement equipment.	Physics, A Human Endeavour: The Nature of Light and Sound 14.1, "Presbycusis" 14.2, "Types of Noises" 14.3, "Sound Pressure Level"
5.1 Explain the concept of threshold of pain.		
5.2 Describe intensity of sound measurement.		

OBJECTIVE	NOTES TO TEACHERS	
5.3 Describe and provide supporting information about the relationship between hearing damage and intensity of sound.		
Section II: Music		
6.0 Describe the characteristics of sound waves in vibrating strings and wires.	Obtain or construct a sonometer.	Physics, A Human Endeavour: The Nature of Light and Sound Activity 14.7, "The Sonometer"
6.1 Explain the production of tones in a wire or string. . fundamental . second harmonic . third harmonic, etc.	The tones can be demonstrated, or preferably produced, by students if enough sonometers are available.	Modern Physics 11.10, "Fundamental Tones" 11.11, "Harmonics" 11.12, "Quality of Sound"
6.2 Use the law of strings to predict vibration frequency in a wire or string.	Solve problems involving the law of strings.	11.13, "Law of Strings"
7.0 Explain the production of resonance as a sympathetic vibration produced by a transfer of energy.	Demonstrate resonance by using tuning forks.	Modern Physics 11.15, "Resonance" Physics, A Human Endeavour: The Nature of Light and Sound 14.8, "Resonance"

OBJECTIVE	NOTES TO TEACHERS	
7.1 Compute the wavelength of sound using resonating air columns.	Perform a laboratory activity on resonating columns.	Physics, A Human Endeavour: The Nature of Light and Sound Experiment 14.3, "Sound in Air Columns" Modern Physics: Laboratory Experiments in Physics Experiment 25, "Resonance: The Speed of Sound
7.2 Relate the speed of sound to resonating air columns.	Solve problems using the theory of open and closed air columns.	
8.0 Distinguish between music and noise.	Have students bring in musical instruments and perform in harmony and disharmony.	Giancoli, Physics 12.4, "Types of Noises"
9.0 Describe the use of wave theory (acoustics) in the design of rooms, concert halls, bridges, etc.	Review the sound wave theories and apply to school and community structures. Watch the film "Fundamentals of Acoustics" available from the Department of Education.	Physics, A Human Endeavour: The Nature of Light and Sound 14.5, "Reflection, Reverberation, and Absorption of Sound"

OPTION II: LIGHT: GEOMETRICAL OPTICS AND OPTICAL INSTRUMENTS TIME: 20-30 Hours

RATIONALE: Vision is crucial to all of us. Our eyes provide us with a large part of our information about the world around us. How do we see? How does light behave in relation to the eye to provide us with the ability to see? Not all aspects of the subject of light will be covered in this unit. This unit will concentrate on an area called geometric optics to illustrate the uses of mirrors and lenses and their applications in optical instruments in modern-day society.

PRIMARY REFERENCES: 1. Paul, Douglas et al. Physics, A Human Endeavour: Unit 4, The Nature of Light and Sound. Toronto: Holt, Rinehart and Winston of Canada, 1976.

OR

2. Williams, John E. et al. Modern Physics. Toronto: Holt, Rinehart and Winston of Canada, 1984.

AND

Williams, John E. et al. Modern Physics: Laboratory Experiments in Physics. Toronto: Holt, Rinehart and Winston of Canada, 1984.

OR

3. Haber-Schaim, Uri et al. PSSC Physics, fifth edition. Toronto: D. C. Heath and Company, 1981.

AND

Haber-Schaim, Uri et al. PSSC Physics Laboratory Guide, fifth edition. Toronto: D. C. Heath and Company, 1981.

TEACHER REFERENCES:

1. Giancoli, Douglas C. Physics. Englewood Cliffs, NJ: Prentice-Hall, 1980.
2. Llowarch, W. and B. Woalnough. Longman Physics Topics: Using Light. London: Longman Group Ltd., 1979.
3. Chaundy, David. Longman Physics Topics: Waves. London: Longman Group Ltd., 1978.

SUPPLEMENTARY REFERENCES:

1. Heath, Robert W. et al. Fundmentals of Physics. D.C. Heath Canada Ltd., 1981. (This text is very useful.)
2. Genzer, Irwin et al. Physics. Morristown, NJ: Silver Burdett, 1973.
3. Laundry, George et al. Physics: An Energy Introduction. Toronto: McGraw-Hill Ryerson Ltd., 1979.

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Define and draw normal, angle of incidence, angle of reflection in relation to plane mirrors.	Have students watch the film, "Light: Part I First Principles and Reflection." This film is available from the Department of Education Library.	Modern Physics 13.2, "Regular and Diffused Reflection" 13.4, "Images by Reflection" 13.5, "Images Formed by Plane Mirrors"
1.1 Locate images in plane mirrors using ray diagrams.		
1.2 Verify the principles of reflection (location of image, relationship between angle of incidence and reflection).	Students can attempt a laboratory activity using pins and plane mirrors.	Modern Physics: Laboratory Experiments in Physics Experiment 27, "Plane Mirrors" PSSC Physics Laboratory Guide, 5th ed. Experiment 28, "Reflection from a Plain Mirror" Activity 18.1, "The Laws of Reflection" Activity 18.2, "Image in Plain Mirrors" Physics, A Human Endeavour: The Nature of Light and Sound Experiment 15.2, "Reflection" Experiment 16.1, "Plane Mirrors"

OBJECTIVE	NOTES TO TEACHERS	
		Giancoli, Physics 21.2, "Characteristics of Light"
2.0 Describe the operation of concave and convex mirrors.	Show the films, "Introduction to Optics" and/or "Spherical Mirrors"	Physics, A Human Endeavour: The Nature of Light and Sound 16.2, "Curved Mirrors"
2.1 Define and illustrate virtual, erect, size, principal axis, principal focus, centre of curvature and spherical aberration.	Have students experiment with curved mirrors.	Modern Physics 13.6, "Curved Mirror Terminology" 13.7, "Rays Focused by Spherical Mirrors" 13.9, "Images Formed by Concave Mirrors 13.10, "Images Formed by Convex Mirrors" 13.12, "Object-Image Relationships" PSSC Physics, 5th ed. 18.3, "Parabolic Mirrors" 18.5, "Images and Illusions" 18.6, "Real and Virtual Images"

OBJECTIVE	NOTES TO TEACHERS	
2.2 Describe images and locate images: . real or virtual . erect or inverted . enlarged, diminished, or same size	Use curved mirrors on an optical bench to show types, shapes and size of images and location of images. Require students to draw images for convex and concave mirrors at all locations: a) infinity b) outside 'c' c) at 'c' d) between 'c' and 'f' e) at focus f) between 'f' and mirror	Modern Physics: Laboratory Experiments in Physics Experiment 28, "Curved Mirrors" Physics, A Human Endeavour: The Nature of Light and Sound Experiment 16.2, "Curved Mirrors"
2.3 Illustrate image location by using ray diagrams.		
2.4 Solve problems using $1/Do + 1/Di = 1/f$ and $M = Di/Do$		
3.0 Define the following terms in relation to lenses: . concave and convex . converging and diverging . refraction and centre of curvature . focal length	Show the films, "Refraction" and/or "Lenses" and illustrate with diagrams. These films are available from the Department of Education Library.	Physics, A Human Endeavour: The Nature of Light and Sound 16.3, "Lenses: Refraction of Light at Curved Surfaces" Modern Physics 14.6, "Types of Lenses" 14.8, "Images by Refraction" 14.11, "Object Image Relationship" 14.12, "The Simple Magnifier"

OBJECTIVE	NOTES TO TEACHERS	
3.1 Describe and locate images: . real or virtual . erect or inverted . enlarged, diminished, or same size	Use an optical bench to illustrate images at all distances from the Modern Physics Laboratory Manual.	PSSC Physics, 5th ed. 19.8, "Lenses" 19.9, "Real Images Formed by Lenses" Physics: An Energy Introduction Modern Physics: Laboratory Experiments in Physics Experiment 30, "Converging Lenses" Experiment 31, "Focal Length of a Diverging Lens" PSSC Physics Laboratory Guide, 5th ed. Experiment 30, "Images formed by a Converving Lens" Experiment 31, "A Diverging Lens"
3.2 Illustrate image location using ray diagrams.	Have students do the experiment, "Refraction," from The Nature of Light and Sound.	Physics, A Human Endeavour: The Nature of Light and Sound Experiment 15.3, "The Refraction"
3.3 Find the focal point of a simple magnifying glass.	Focus the sun at a point but use coloured glass to do so. CAUTION: This can cause ultra violet damage to the retina. An alternative is to use an optical bench.	

OBJECTIVE	NOTES TO TEACHERS	
3.4 Solve problems using: $1/Do + 1/Di = 1/f$ and $M = Di/Do$		
4.0 Apply what he/she has learned about lenses to simple optical instruments.		
4.1 Describe the use of lenses in a telescope (focal length, objective lens, eyepiece, distance between lenses, and magnification).	The teacher should have access to a telescope that can be taken apart. Build a model telescope.	*Physics, A Human Endeavour: The Nature of Light and Sound* Activity 16.5, "Making a Telescope" 16.5, "To See the Small and Distant" *Modern Physics* 14.13, "The Microscope" 14.14, "Refracting Telescope" *Longman Physics Topics: Using Light* *Physics: An Energy Introduction* 18.1, "The Pinhole Camera" 18.2, "The Modern Camera"

OBJECTIVE	NOTES TO TEACHERS
	18.7, "Refracting Telescopes" 18.8, "Reflecting Telescopes"
4.2 Describe the uses of lenses in the microscope and how such large magnification occurs. Be able to illustrate with a ray diagram.	
4.3 Apply the principles of lenses and mirrors to binoculars and reflecting telescopes.	Have a pair of binoculars and/or a simple camera available for students to take apart and examine.
4.4 Describe the principle of operation of a simple camera.	

OPTION III: SUNBURN TIME: 15-20 Hours

RATIONALE: Life would be impossible without light from the sun. Sunlight (solar radiation) allows warmth and energy, vision and photoresponses, photosynthesis, and vitamin D synthesis. But there are also adverse effects. A particular adverse effect of current concern is the over-exposure of human skin to solar radiation.

PRIMARY REFERENCE: 1. Henriksen, Peter N. and Paul Payerle. Sunburn and Sunscreens. Stony Brook, NY: American Association of Physics Teachers. (Mimeo)

SECONDARY REFERENCES:

1. Goody, A.M. et al. Atmosphere. Englewood Cliffs, NJ: Prentice-Hall, 1972.
2. Giese, A.C. Living with our Sun: Ultraviolet Rays. New York: Plenum Press, 1976.

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Describe waves.		
1.1 Recall from previous study of wavelength, the relationship of v, f, and λ.	Assign problems using $v=f\lambda$ from Modern Physics or PSSC: 5th ed.	Modern Physics, 10.6, "Characteristics of Waves" Giancoli, Physics 11.6, 11.8, 12.1, 12.4, 12.5
1.2 Describe the different types of waves on the electromagnetic spectrum and physical dangers of these waves.		Sunburn and Sunscreens "Electromagnetic Spectrum"
1.3 Describe diffraction of mechanical waves and light waves.	Build a shoebox spectroscope. Warn students of the danger of using the spectroscope for sun viewing.	Sunburn and Sunscreens "Diffraction of Light"
1.4 Describe light which cannot be detected by the human eye.	Detect ultraviolet light using a modification of the spectroscope.	Sunburn and Sunscreens "Detecting Ultraviolet Light"
1.5 Determine the wavelengths of light.		
1.6 Do problems on wavelength of spectral lines.		

OBJECTIVE	NOTES TO TEACHERS	
2.0 Describe how solar radiation is filtered out by the earth's atmosphere depending upon wavelength and intensity of the radiant energy.		
2.1 Describe photoionization and photodissociation (absorption processes).		Sunburn and Sunscreens "The Earth's Atmosphere as a Filter of Solar Radiation"
2.2 Describe the ultraviolet range and subranges of light waves (UVA, UVB and UVC).	Assign questions from Sunburn and Sunscreens.	Atmosphere
3.0 Be aware of and describe the damage that can be done to the skin by solar radiation.		Sunburn and Sunscreens "Skin Damage Caused By Solar Radiation and Sunscreens"
3.1 Describe the anatomy of the human skin.		
3.2 Describe and explain sunburn--short- and long-term effects.		
4.0 State methods of preventing damage by sunburn (sunscreen).		

OBJECTIVE	NOTES TO TEACHERS	
4.1 Describe the properties of an ideal sunscreen (physical and chemical).		Sunburn and Sunscreen "Relative Effectiveness of Commercially Available Sunscreens" Method 1: "Absorption Spectroscopy with Monochrometer" or Method 2: "Absorption Spectroscopy with Shoebox Spectroscope"
4.2 Relate the absorption of wavelengths to the effectiveness of chemical sunscreens.		
4.3 Describe protection factor for chemical sunscreens.	If unable to do experiment to Comparison Project, do activity on page 42 of Sunburn and Sunscreens.	

OPTION IV: HISTORICAL DEVELOPMENT OF THE ATOMIC THEORY TIME: 20 Hours

RATIONALE: The study of the atom has been one of the most exciting branches of physics in the last century. Progress in the study of the atom has advanced not only in pure science but also technology, which supplies both the tools for research and applies some of the results of research in practical ways. These applications, including the production of electricity from nuclear energy, the many clinical and industrial uses of radiation and, of course, the military weapons, have had economic, social and political consequences. This unit concentrates on the early historical development of the atomic theory. If time permits, teachers may want to expand the unit to include some of the more modern discoveries in nuclear energy or basic nuclear particles.

PRIMARY REFERENCES: 1. Paul, Douglas. Physics, A Human Endeavour: Unit 6, The New Physics. Toronto: Holt, Rinehart and Winston of Canada Ltd., 1976.

SUPPLEMENTARY REFERENCES:

1. Holton, G. et al. Project Physics Text. Toronto: Holt, Rinehart and Winston of Canada, 1980.
2. Williams, John E. et al. Modern Physics. Toronto: Holt, Rinehart and Winston of Canada, 1984.
3. Laundry, George et al. Physics: An Energy Introduction. Toronto: McGraw-Hill Ryerson Ltd., 1979.
4. Stohlberg, Robert et al. Physics: Fundamentals and Frontiers. Toronto: Houghton Mifflin Company, 1980.
5. Heath, Robert W. et al. Fundamentals of Physics. D. C. Heath Canada Ltd., 1981.

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 State reasons for the acceptance of the atomic molecular theory, i.e., x-ray diffraction in crystals, thickness of an oil film, brownian motion, concept of pressure, diffusion and definite proportions in chemistry.	Watch the films "Crystals and their Structures" and "Osmosis." Demonstrate how diffusion and brownian motion work.	
2.0 State the early historical development of modern atomic theory including: . discovery of cathode rays; . discovery of x-rays; . discovery of the electron; . the Rutherford and Thompson models and the evidence for the acceptance or rejection of each.	Do a Wilson Cloud Chamber demonstration if the equipment is available. NOTE: Experiments described in The New Physics, chapter 21, may give off harmful x-rays. Safety of available equipment should be checked using the data in Safety in Science. Watch the film "Rutherford Atom."	Physics, A Human Endeavour: The New Physics 21.1, "The Need for a Change" 21.2, "Cathode Rays" 21.3, "Mysterious Rays" 21.4, "Discovering the Electron" Physics, A Human Endeavour: The New Physics 22.5, "The Nuclear Atom" 22.6, "The Search for a Stable Atom"
3.0 Outline the development of the theory of quantum mechanics including:		

OBJECTIVE	NOTES TO TEACHERS	
. Plancks equation (E=hν) . Hot Body Radiation . The Photoelectric Cell . The Bohr Atom . Waves of Matter	View both absorption and emission spectra. Student spectrascopes are listed as equipment for both IPS and PSSC courses. Discuss and show examples of photoelectric cells such as camera light meters and burglar alarms.	Ideas and Discoveries in Physics "The New Mechanics"
4.0 State the principles of radioactivity in terms of: . Becquerel's discovery . Discovery of α and β rays and their properties . Radioactive decay rates . Radioactive decay patterns	Becquerel's discovery can be duplicated by using radioactive materials from the IPS course.	Physics, A Human Endeavour: The New Physics 21.5, "Discovering Radioactivity" 21.6, "Other Radioactive Elements" 21.7, "Identifying the Radiation" 21.8, "The Nature of Radioactivity" 21.9, "Radioactive Decay" 23.2, "Radioactive Transformations"
5.0 Define the nature of isotopes in terms of their structure, relationship to elements, atomic weight and radioactivity. 5.1 Describe and apply decay transformation rules.	Use Activity 23.1 from The New Physics to illustrate the concept of isotopes. Use simulated samples (in containers) of isotopes in relative proportions for some isotopes from the nuclide chart and have students find the characteristics.	Physics, A Human Endeavour: The New Physics 23.3, "Isotopes" 23.4, "Measuring the Mass of Isotopes" 23.6, "Decay Equations and Transformation Rules"

OBJECTIVE	NOTES TO TEACHERS	
5.2 Describe artificial transmutations.	Teachers may wish to extend the unit by dealing with nuclear energy, nuclear binding energy, nuclear stability, fission and fusion, and newer nuclear models such as the "liquid drop" and "shell" models.	23.7, "Artificial Transmutation--The Alchemist's Dream"
6.0 Describe evidence for the proton-electron-neutron model of the atom; the neutrino.		23.8, "The Proton--Electron Model of the Nucleus" 23.9, "The Neutron" 23.10, "The Mystery Behind β Decay"

OPTION V: EARTHQUAKE PREDICTION

RATIONALE: Earthquakes are natural phenomena involving large amounts of energy. The cost of earthquakes in terms of destruction and human suffering can be enormous. To minimize the damage, humans can try to manage the earthquakes or predict their occurrence and take steps to minimize their effects when they occur. The latter approach seems to be the most practical.

PRIMARY REFERENCE: *1. Silverman, Wayne. Earthquake Prediction. Stony Brook, NY: American Association of Physics Teachers. (Mimeo)

SUPPLEMENTARY REFERENCES:

1. James, J.R. Geology and the New Global Tectonics. Toronto: The Macmillan Company of Canada Ltd., 1976.
2. Matthews, William H. et al. Investigating the Earth, third edition. Boston: Houghton Mifflin, Co., 1978.

* Student copies or a single copy could be obtained and appropriate sections copied for students.

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Describe the characteristics of earthquake waves and use these characteristics in the study of prediction methods.	Exercises 1-3 are easily done. The slinky mentioned is available from suppliers of the PSSC equipment.	Earthquake Prediction Segment 1 "Earthquake Wave"
	The answers for the exercises are given on pages 56 and 57.	Investigating the Earth Chapter 16, "Earthquakes and the Earth's Interior" (supplementary reference with good diagrams)
1.1 List the parameters used to specify an earthquake prediction.		
1.2 Describe the relationship between the Richter scale and magnitude of an earthquake.		
1.3 Compare the success record of China and the U.S. in earthquake predictions.		
1.4 List the properties of the three types of earthquake waves.	Problems and activities are found on pages 25 to 28 in Earthquake Prediction.	
1.5 Explain what a travel-time graph shows.		
2.0 State the theories about the causes of earthquakes.		
2.1 Explain briefly the history of the theory of Continental Drifts.		

OBJECTIVE	NOTES TO TEACHERS
2.2 Describe the current concepts about the mechanism of sea floor spreading.	
2.3 List the five lines of evidence for plate tectonics.	
2.4 Determine the drifting distances given rock polarity data.	
2.5 Determine age and rate of movement given rock polarity data.	
3.0 State various prediction methods and relationships.	Earthquake Prediction Segment III, "Prediction Methods and Relationships"
3.1 List the mechanisms associated with the dilatency effect.	The written exercise in Earthquake Prediction has the required information with it.
3.2 Explain recurrence rates and use a recurrence rate graph.	
3.3 Use a graph relating uplift to magnitude.	
3.4 Explain the significance of wave velocity changes.	

OBJECTIVE	NOTES TO TEACHERS
List some of the observed abnormal animal behaviour prior to earthquakes.	
Describe some of the uncertainties involved in issuing predictions.	

OPTION VI: ENERGY FUTURES (OPTIONS VIa, VIb)

GENERAL RATIONALE:

The continued availability of energy resources and the need to identify and develop energy alternatives and appropriate technologies is a question which will be resolved over the long term. In the meantime, we must acknowledge that the rate at which finite energy resources are used and the nature of alternatives have implications for the amount and kind of world economic growth and even for a personal need to re-examine the relationship of one's lifestyle to the use of energy.

Although this topic can be developed in a variety of ways and with several emphases, this grouping of units will attempt to provide both a basic design and some flexibility by offering the following choices:

Option VIa: Energy Futures--Nature of the Resource. This unit is concerned with examining the nature of energy and its conversion, finiteness of resources (non-renewable) and factors which affect future availability. This unit can be combined with Unit VIb in part or completed in total depending upon students' pre-knowledge and perception of the need to examine future resource availability.

Option VIb: Energy Alternatives to Fossil Fuels. The general direction of this unit is that of examining alternative sources, their technologies and potential, risks and trade-offs, and a comparison of the potential of alternatives. NOTE: Solar Energy is a possible option in Grade XI. If teachers wish to do a comparison of these two energy alternatives, they may wish to do another option in Grade XI and combine the Solar Energy option with Energy Alternatives (nuclear). Alternatively, solar and nuclear could be done in less depth; combined with other alternative sources, and comparisons made among alternatives by using simulations and/or other materials. Teachers should be aware that some concepts overlap with the unit on Historical Development of the Atomic Theory could occur; however, the intent and perspectives of the two units are different.

Although the two units are related, a teacher may wish to emphasize one part over another or do one section only. The latter possibility, however, does not provide a balanced view of energy options. Cooperation among natural and social science teachers within the school could have very positive results. Depending upon the depth desired and degree to which alternatives are examined, these units can easily require 30 hours of work. Physics teachers should make themselves aware of the potential for energy education which is available in the new Chemistry 200 options.

OPTION VIa: NATURE OF THE RESOURCE

RATIONALE: In order to place the potential of energy alternatives into perspective, it may be worthwhile to present students with an opportunity to review the present status of energy sources, i.e., the kinds and estimated present reserves, factors affecting their potential, and the uncertainty of prediction. Since it is possible for students to examine aspects of this unit in Fossil Fuels (a Science 100 option) teachers should become familiar with students' backgrounds. On the basis of this information teachers may wish to eliminate or drrastically modify this toption. In order to bring the "energy equation" into perspective for the student, this unit will examine some of the factors which affect decisions concerning energy resources: 1) efficiency of energy conversion into "useful" energy; 2) energy consumption and industry; and 3) growth efffffects and uncertainties of prediction.

Teachers should refer to the general rationale on the preceeding pages for information about some alternative approaches to units VIa and VIb.

PRIMARY REFERENCES:

1. Marion, Jerry B. and Marvin L. Rousch. Energy in Perspective, second edition, Toronto: Academic Press, 1982.

AND

2. Webb, Madelyn. The Canadian Environment: Data Book on Energy and Environmental Problems. Toronto: W. B. Saunders Company, 1980. (Single copy only required, available from Department of Education Library.)

OR

1. Lewis, John L. (project director). Science in Society: Teacher's Guide. London: Heinemann Educational Books Ltd., 1981.

AND

2. Webb, Madelyn. The Canadian Environment: Data Book on Energy and Environmental Problems. (A copy may be borrowed from the Department of Education Library.)

SUPPLEMENTARY RESOURCES:

1. Phillips, Hugh (program director). SEEDS: Energy Systems and Teacher's Resource Book: Energy Systems. Toronto: Science Research Associates (Canada) Ltd., 1983. (This is an excellent resource book; however, it is designed for Grade X and is very useful in the Fossil Fuels unit.)
2. Energy Management for the Future. Ottawa: Energy, Mines and Resources Canada.

3. Ruedisili, Lon and Morris Firebaugh. *Perspectives on Energy: Issues, Ideas and Environmental Dilemmas*. New York: Oxford University Press, 1978.

4. Waring, Gene. "Energy and the Automobile." *The Physics Teacher*. October 1980.

5. Solomon, Joan. *SISCON: Energy, The Power to Work*. Oxford: Basil Blackwell Publishers Ltd., 1983.

6. Kantrowicz, Arthur and Richard Ross. "MHD Power Generation." *The Physics Teacher*. November 1975.

7. *Fossil Fuels*. Winnipeg: Manitoba Department of Education, 1981.

8. *Scientific American*, 224:142; September 1971.

9. *Energy Efficient Housing: A Prairie Approach*. Manitoba Energy and Mines, 1981.

10. *100 Ways to Save Energy and Money in the Home*. Ottawa: Energy, Mines and Resources Canada, 1979.

11. Shell Canada Briefing Papers. *Canada's Oil and Gas Reserves* and *Developing the Tar Sands*. (Single copies available from Shell Canada.)

12. Bartlett, Albert. "The Exponential Function: Parts I, II, and III." *The Physics Teacher*. October 1976.

13. Bielenstein, H.U. *Coal Resources and Reserves of Canada*. Ottawa: Energy, Mines and Resources Canada, 1979.

14. *Coal in Canada*. Ottawa: Energy, Mines and Resources Canada, 1979.

15. *Electric Power in Canada*. Ottawa: Energy, Mines and Resources Canada, 1979.

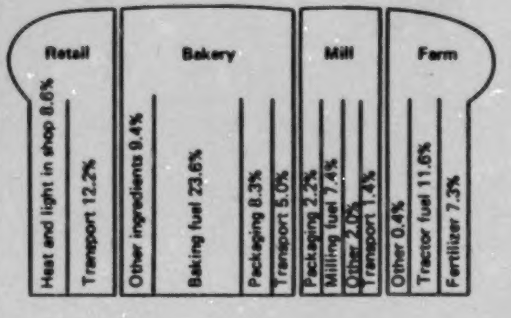
AUDIO-VISUAL RESOURCES:

1. "Energy Management for the Future." National Film Board.

2. "Energy" (Imperial Oil). Canfilm Screen Services.

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Define work, power and energy.	These concepts should have been developed in the "core." Review only as required.	Energy in Perspective Chapter 2, "Work, Energy and Power" SEEDS: Energy Systems
1.1 Apply formulae in work, power and energy relationships.	Students can conduct an experiment to determine relationships between mass or height and potential energy.	
1.2 Describe ways in which energy can be converted from one form to another, e.g., chemical to electrical, mechanical to heat.	Discuss different systems of energy transformation and have students trace the flow of energy through various systems. Teachers may wish to use input-output models of other conversion systems such as the conversion of fuel, oxygen, and electricity by a gasoline engine to hydrocarbons, mechanical energy, heat, water, noise and nitrogen oxide.	

OBJECTIVE	NOTES TO TEACHERS	
1.3 Define efficiency in energy systems and describe the input and output of some systems as related to efficiency, e.g., coal burning electrical generating plants or the automobile.	A typical coal burning plant is about 35 to 40% efficient with heat losses from stock gases (about 10%) in cooling water (50%) and electrical transmission losses (about 30%). Discuss how and why losses occur. Students should be aware that total energy is conserved. Rolling efficiency of utomobiles may be about 10%.	Energy in Perspective Chapter 2, "Work, Power and Energy", Section: "Efficiency in Energy Conversions" Perspectives on Energy Chapter 7, "Energy and the Environment" The Canadian Environment: Data Book on Energy and Environmental Problems "Energy" Fossil Fuels
1.4 Describe energy costs in total systems such as producing food, metals, or in life systems.	Although the ideas are similar to those found in earlier examples, teachers may wish to illustrate that some "man-made" systems may subsidize outputs very heavily. For example, Peter Chapman in Fuels Paradise (Penguin Publishers) claims primary fuel requirement for producing a loaf of bread of about 20 MJ to obtain an output of about 14 MJ. The following diagram illustrates an approximation of energy requirements.	Science in Society: Teacher's Guide "Energy" Perspectives on Energy "Energy Use in the United States Food System" SEEDS: Energy Systems "Energy in a Life System"

OBJECTIVE	NOTES TO TEACHERS	
	 (Source: Lewis, Science in Society: Teacher's Guide.) In addition, about 30% of the primary fuel may be used to produce, transport and convert fuels.	
2.0 Explain the formation of fossil fuels. 2.1 Describe the locations and potential extent of fossil fuel reserves.	The objective could have been covered thoroughly in Science 100, so teachers may wish to review this area quickly.	The Canadian Environment: Data Book on Energy and Environmental Problems Fossil Fuels

OBJECTIVE	NOTES TO TEACHERS	
3.0 Describe world and energy consumption (fossil fuels) relative to: . energy consumption and its relationship to GNP . energy consumption by various sectors of the economy, e.g., transportation . comparative consumption among countries	Use graphs and tables from The Canadian Environment to examine and discuss questions of use, potential present sources of fossil fuels, hydroelectric power. You may wish to discuss the uncertainty of predicting requirements, and reserves (refer to scenarios on "Changing Patterns of Energy Supply" and "Canadian Energy Supply Scenarios" from The Canadian Environment). The difficulties and uncertainties of predicting future availability should be examined.	Science in Society: Teacher's Guide The Canadian Environment: Data Book on Energy and Environmental Problems Fossil Fuels Energy in Perspective "Sources of Energy" and "Energy Consumption: Today and the Future" SEEDS: Energy Systems SISCON: Energy, The Power to Work
3.1 Relate the effects of various factors upon predicting the availability of fossil fuels. . define exponential growth and calculate its potential effect upon future availability of fossil fuels		

OBJECTIVE	NOTES TO TEACHERS	
	Note that other factors such as structural changes in the nature of the industry (e.g., microelectronics, increasing efficiencies of systems, and conservation effect the relationship of GNP and energy use).	The Physics Teacher "The Exponential Function - Part I" "The Exponential Function - Part II"
. relate Hubbert's curves to estimating resource potential	An interesting simulation which illustrates Hubbert's technique of estimating reserves is found in SEEDS: Energy Systems. The simulation can be applied to resource location.	Perspectives on Energy "Survey of World Energy Reserves" SEEDS: Energy Systems "Energy-System Limits"
. relate the potential effect of other factors upon resource availability, e.g., conservation . critically analyze the arguments for conserving resources	Teachers may wish to refer to earlier graphs illustrating the effects of various factors upon resource use (including cost). Some graphs are illustrated above and others can be found in the Level III document, Fossil Fuels. Energy audits can be done and effects of methods of conservation examined. Students can analyze energy systems and conservation of them in terms of the potential effects environmentally, economically (standard of living), etc.	SEEDS: Energy Systems "Energy Systems in Balance" Fossil Fuels The Canadian Environment: Data Book on Energy and Environmental Problems Science in Society: Teacher's Guide

OPTION VIb: ALTERNATIVES TO FOSSIL FUELS TIME: 15 Hours

RATIONALE: Teachers should refer to the general rationale for information about the relationship between units VIa and VIb.

The general intent of this unit is that of examining alternative sources of energy, the potential of related technologies, risks and trade-offs, and a comparison of the potential of alternatives. NOTE: Solar energy is a possible option in Grade XI. If teachers wish to do a comparison of these two energy alternatives, they may wish to do another option in Grade XI and combine the Solar Energy option with Energy Alternatives (nuclear). Alternatively, solar and nuclear could be done in less depth; combined with other alternative sources, and comparisons made among alternatives by using simulations and/or other materials. Teachers should be aware of the possibility of some concept overlap with the unit on Historical Development of the Atomic Theory; however, the intent and perspectives of the two units are different.

PRIMARY REFERENCES:

*1. Marion, Jerry B. and Marvin L. Rousch. Energy in Perspective, second edition. Toronto: Academic Press, 1982. (Uses U.S. technology.)

2. Webb, Madelyn. The Canadian Environment: Data Book on Energy and Environmental Problems. Toronto: W.B. Saunders Company, 1980. (Single copy only required, available from Department of Education Library.)

OR

*1. Jenkins, Frank (director). ALCHEM: Nuclear Chemistry. Edmonton: J. M. LeBel Enterprises Ltd., 1980.

AND

2. Webb, Madelyn. The Canadian Environment: Data Book on Energy and Environmental Problems. Toronto: W.B. Saunders Company, 1980. (Available from Department of Education Library.)

OR

*1. Lewis, John L. (project director). Science in Society: Teacher's Guide. London: Heinemann Educational Books Ltd., 1981.

2. ----------. Science in Society: Energy (Book F).

* In order to provide more balance either in terms of Canadian technology or in terms of examining alternative technologies and risk, single copies as teacher reference should be added to either of the above alternatives.

The following materials do not provide the depth of scientific content found in some other references (as presented in Part I, Nuclear Energy) and deals with a broader perspective in terms of alternatives which are based on physics and chemistry principles. However, the materials provide a mechanism for examining the potential of alternative energy technologies at a general level.

OR

1. Phillips, Hugh (program director). SEEDS: Energy Technologies. Toronto: Science Research Associates (Canada) Ltd., 1983.

2. ----------. SEEDS: Energy Technologies (Teacher's Resource Book).

AND/OR

1. Phillips, Hugh (program director). SEEDS: Energy in the Future. Toronto: Science Research Associates (Canada) Ltd., 1983.

2. ----------. SEEDS: Energy in the Future (Teacher's Resource Book).

SUPPLEMENTARY REFERENCES:

Decision-Making Simulation Exercises. (Case studies useful in applying some factors to examining alternatives.)

1. Lewis, John L. (project director). Science in Society: Alternative Energy Project.

2. ----------. Science in Society: Power Station Project.

SECONDARY REFERENCES:

*1. Ruedisili, Lon and Morris Firebaugh. Perspectives on Energy: Issues, Ideas and Environmental Dilemmas, second edition. New York: Oxford University Press, 1978.

2. Nguyen, Van Thank. Geothermal Energy: Resource and Utilization. Stony Brook, NY: American Association of Physics Teachers, 1979.

Levine, Melvin M. Fission Reactors. Stony Brook, NY: American Association of Physics Teachers, 1981.

Fillo, J. A. Introduction to Nuclear Fusion Power and the Design of Fusion Reactors. Stony Brook, NY: American Association of Physics Teachers, 1981.

Lindenfeld, Peter. A Summary of Some Properties of Nuclei, Nuclear Radiation and Reactors. Stony Brook, NY: American Association of Physics Teachers, 1980.

All of the above modules could serve as teacher references, if additional data or depth is required.

3. Boulton, I. (editor). Management of Radioactive Fuel Wastes: The Canadian Disposal Program. Pinawa: Whiteshell Nuclear Research Establishment, Atomic Energy of Canada Limited, 1978.

4. Clark, Wilson. Energy for Survival: The Alternative to Extinction. New York: Anchor Press, Doubleday, 1974.

5. Saperstein, Alvin M. Physics: Energy in the Environment. Boston: Little, Brown and Company, 1975.

6. Arenson, Ken (chairperson). Nuclear Energy: Fact and Fantasy. Winnipeg: Manitoba Environmental Council, 1975.

*7. Articles from the Physics Teacher:

Levin, Franklyn. "The Physics of Oil Exploration." January 1976.
Cohen, Bernard, L. "Health Risks of Nuclear Power." November 1978.
Bushong, Stewart, C. "Radiation Exposure in our Daily Lives." March 1977.
Devaney, Joseph J. "Physics-related Problems of Coal-fired Power Plant Pollution." September 1978.
Kantrowicz, Arthur and Richard Rosa. "MHD Power Generation." November 1975.
Firebaugh, Morris W. "Perspectives on Energy and the Environment." February 1979.
Findl, Eugene. "Physics and the Electric Car." February 1977.
Waring, Gene. "Energy and the Automobile." October 1980.
Smith, Morton C. "Geothermal Energy: The Energy in the Basement." November 1978.
Patrinos, A.A. "Power Plant Induced Rainfall Modification: Fact or Fiction." March 1981.

*8. Cromie, William J. "Which is Riskier--Windmills or Reactors?" Sciquest. Vol. 53, No. 3, March 1980.
Inhaber, H. "Risk with Energy from Conventional and Nonconventional Sources." Science, February 1979.
Lemberg, R. and R. Coysuto. "Letters." Science, May 1977. (Critical of Inhaber report in footnote 2.)

SECONDARY REFERENCES:

9. Electric Power in Canada. Ottawa: Energy Policy Sector, Energy, Mines and Resources Canada, 1975.

10. Electric Power in Canada. Ottawa: Energy, Mines and Resources Canada, 1979.

*11. Energy Alternatives: Report of the Special Committee on Alternative Energy and Oil Substitution. Ottawa: Energy, Mines and Resources. The Parliament of Canada, Canadian Government Publication Centre, Supply and Services Canada, 1981.

AUDIO-VISUAL: The following films are available from Manitoba Hydro, Box 815, Winnipeg, Manitoba, R3C 2P4

1. "At Your Fingertips"
"Nuclear Energy"
"Accident Safe"
"Douglas Point Nuclear Power Station"
"Energy Realities"
"Isotopes in Action"
"This Nuclear Age"
"Nuclear Fuel Waste Management"
"Challenge of the Nelson Powerline"
"Electricity--Handle with Care"

A film catalogue with descriptions of films is available from Manitoba Hydro.

* These publications would be very useful as references.

OBJECTIVE	NOTES TO TEACHERS	
NUCLEAR ENERGY (PART I) The student should be able to:		
1.0 Describe the characteristic properties of nuclear radiation (alpha, beta, and gamma).	Compare radiation in terms of mass, penetrating abilities and relationship to nuclear particles.	ALCHEM: Nuclear Chemistry "Discovery of Radioactivity: Identifying Nuclei" Energy in Perspective 6, "The Effects of Nuclear Radiations"
1.1 Describe mechanisms for detecting radioactivity.	Demonstrate detection of various kinds of radioactivity by using a cloud chamber and geiger counter.	
1.2 Describe the Rutherford model of the atomic nucleus, relate the model to the experimental data obtained and the basis for accepting this model.	Provide the experimental data obtained by Rutherford's experiments and relate this to a model and why it is more acceptable than other models such as the raisin-pudding model.	
1.3 Use isotope notation and relate this to the structure and possible uses of selected isotopes.		

OBJECTIVE	NOTES TO TEACHERS	
2.0 Relate the stability of nuclei to factors such as binding energy and mass number.	Use a graph of binding energy and mass number to relate stability to various isotopes. Relate neutron-proton combinations to stability.	ALCHEM: Nuclear Chemistry "Factors Affecting Nuclear Stability" Energy in Perspective 5, "Nuclear Power" Science in Society: Energy SEEDS: Energy Technologies 3, "Energy Technologies of Oil and Electricity"
2.1 Write nuclear equations.		
2.2 Describe radioactive decay and relate decay to a nuclear model and transmutation.		
2.3 Differentiate between nuclear fusion and fission.		
2.4 Compare fusion and fission as controlled reactions to produce energy (advantages and disadvantages).		

OBJECTIVE	NOTES TO TEACHERS	
3.0 Relate nuclear binding energy to fission and fusion.		ALCHEM: Nuclear Chemistry Part 2, "Nuclear Reactions"
3.1 Calculate energy changes associated with nuclear reactions.		
3.2 Compare energy changes (phase, chemical, nuclear) in terms of quantity of available energy, application and technological possibilities at present.	Phase changes (least energy) are applied to steam heating, refrigeration, etc., chemical changes in electrochemical cells and biological processes, and nuclear (high energy) to generating electricity.	
4.0 Compare the CANDU system and other nuclear reactors (such as the U.S. LWR reactors), conventional power plants in terms of kinds of fuel used, processes (e.g., absorption of particles mechanism, wastes produced, potential environmental effects; efficiency.	Set up a chart with the criteria to be compared. Have students make reports relative to the various criteria including uncertainty of data, where applicable. If the concept of risk was not developed in the Facts unit in Grade XI, this could be a place to introduce this concept. The film and teacher's guide for "How Safe is Enough?" is available from the Department of Education Library. Introducing the concept of risk can also be delayed until one examines alternate energy systems such as geothermal, solar, etc. The SEEDS material uses heat quality and efficiency as one of the	Film, "How Safe is Enough?" On the Perception and Evaluation of Risk: Teacher's Guide ALCHEM: Nuclear Chemistry Part 4, "Nuclear Reactions and the CANDU System" Energy in Perspective "Nuclear Power" and "Benefit vs. Risk"

OBJECTIVE	NOTES TO TEACHERS	
	factors for examining alternates. The simulation Power Station Project may be used to introduce some of the factors to be considered in locating a station.	**Sciquest** "Ionizing Radiation and the Nuclear Reactor" **The Physics Teacher** "Health Risks of Nuclear Power" "Radiation Exposure in our Daily Lives" "Physics-related Problems of Coal-fired Power Plant Pollution" "MHD Power Generators" "Power Plant Induced Rainfall Modification: Fact or Fiction" **Management of Radioactive Fuel Wastes: The Canadian Disposal Program** **The Canadian Environment: Data Book on Energy and Environmental Problems**
EXTENSION 5.0 Describe the role of nuclear reactors relative to applications in nuclear chemistry: . power generators . research . isotopes in agriculture and medicine	Have students report on the various applications of nuclear materials and processes such as isotopes.	**ALCHEM: Nuclear Chemistry** Part 5, "Applications of Nuclear Reactors"

OBJECTIVE	NOTES TO TEACHERS	
. the production of fuels (breeder reactors).		
ALTERNATIVE SOURCES (PART II)		
1.0 Describe methods for harnessing renewable sources of energy such as wind, geothermal and tidal.	The concept of risk can be introduced here, if not introduced earlier in the unit. Compare alternatives such as solar, wind and hydroelectric power as potential, future alternaitves in a simulation. This can also be used to "force" students to examine the relevant data from various source materials. An alternative approach is the use of reports.	Energy in Perspective "Sources of Energy" Science in Society: Energy "Alternative Sources of Risk," "Risks of Energy Provision," "Statistics and Risk" The Canadian Environment: Data Book on Energy and Environmental Problems "Alternative Energy Sources - Soft Path"
2.0 Interpret and evaluate the feasibility of alternative energy sources.		Science in Society Simulations: Power Station Project or Alternative Energy Project. May be used in conjunction with teacher references and articles to examine alternatives. SEEDS: Energy Technologies "Extending Energy Technologies in Use" SEEDS: Energy in the Future

OPTION VII: SCIENCE, TECHNOLOGY AND SOCIETY TIME: 10-15 Hours

RATIONALE: Changes in the quantities of energy which are required, population growth, living standards, the knowledge of science and availability of technology are some of the interrelated factors which can affect the future. Since no one factor stands by itself, it is important that students be provided with opportunities to examine the interrelationships and potential effects of these factors upon the future. Students should understand that exponential growth is not possible in a finite world and should learn to consider the future expectations and the quality of life. In addition, although limits exist, it is important tht students be aware of and examine potential alternative actions. Although the materials identified for this topic are British, many of the ideas are general and can be related to specifics in North America by using current articles. A cooperative effort among natural science, computer science, and social science teachers might be useful.

PRIMARY REFERENCES:

1. Lewis, John L. (project director). Science in Society: Teacher's Guide. London: Heinemann Educational Books Ltd., 1981.
2. Lewis, John L. (project director). Science in Society: Looking to the Future (Book L). London: Heinemann Educational Books Ltd., 1981.

SUPPLEMENTARY REFERENCES:

1. Meadows, D.H. et al. The Limits to Growth. New York: New American Library. (Paperback)
2. Ehrlich, Paul R. and Anne H. Ehrlich. Population, Resources Environment. San Francisco: W.H. Freeman and Company, 1970.
3. Solomon, Joan. SISCON: Technology, Invention and Industry. Oxford: Basil Blackwell Publisher Ltd., 1983.
4. ----------. SISCON: The Atomic Bomb. Oxford: Basil Blackwell Publisher Ltd., 1983.
5. Maddox, John. Doomsday Syndrome: An Assault on Pessimism. New York: McGraw-Hill, 1972.
6. The Ecologist (editor). The Blueprint for Survival. New York: New American Library, 1972.

7. Ward, Barbara and Rene Dubos. Only One Earth. New York: W. W. Norton, 1972.

8. Schumacher, E. F. Small is Beautiful: Economics as if People Mattered. New York: Harper and Row, 1975.

9. ----------. Scientific American. Volume 237, No. 3. September 1977. (Microelectronics issue.)

10. Lewis, John L. (project director). Science in Society: Defense and Energy Issues (Book P). London: Heinemann Educational Books Ltd., 1983.

AUDIO-VISUAL REFERENCES:

1. Schumacher, E.F. Limits to Growth and its Detractors. C.B.C. Learning Systems. (Tape cassette.)

2. ----------. Limits to Growth and its Proponents. C.B.C. Learning Systems. (Tape cassette.)

3. The Robots are Coming (a film).

The above materials are available from the Department of Education Library.

OBJECTIVE	NOTES TO TEACHERS	
The student should be able to:		
1.0 Describe the effect of exponential growth upon: . doubling time . finite resources	Review from Unit VIa. Relate exponential growth to time by demonstrating doubling time using squares of paper and covering an area.	Science in Society: Teacher's Guide Energy in Perspective
2.0 Relate positive and negative feedback loops to growth and growth models.	Describe feedback loops in a simple situation such as the thermostat and apply the concept to bacterial populations, industrial or other kinds of growth. This should lead to discussion of the S-curve and factors affecting this type of growth.	Science in Society: Teacher's Guide
3.0 Describe the interrelationships between finiteness of resources and growth (population, food and industrial requirements, resource development, environmental factors, technologies).	Use the tape cassette, Limits to Growth, or information from the book to discuss interrelationships and questions such as: "What are essential requirements for a population? What are basic needs for an adequate food supply? What are some feedback loops relating food production, population, industrial activity, waste production and health?	Limits to Growth and Its Proponents Limits to Growth and Its Detractors Science in Society: Teacher's Guide
3.1 Relate feedback loops to both growth and steady state models.	Discuss factors affecting growth and stable states, e.g., implications of recycling materials, conservation, pollution. Illustrate, using graphical relationships.	Science in Society: Teacher's Guide "Limits to Growth"

OBJECTIVE	NOTES TO TEACHERS	
3.2 Describe some of the weaknesses and strengths of the "Limits of Growth" model and describe some technological needs and alternatives.	Discuss the possibilities as described in "Chemistry and the New Industrial Revolution."	Science in Society: Looking to the Future "Man and His Environment: Crisis or Climacteric" and "Chemistry and the New Revolution"
4.0 Describe both the potential and the limitations of science and technology for resolving future problems.		
4.1 Relate kinds of technology to factors such as replacement of people, size of technology, job satisfaction.	Discuss limitations and factors affecting the kinds of technology after reading "Appropriate Technology."	Science in Society: Looking to the Future "Appropriate Technology" Small is Beautiful: Economics as if People Mattered
4.2 Describe a potential role for science in helping decision makers.	Read "Science and Potential Decisions" and "War in the 20th Century" or provide students with a copy of Einstein's letter to President Roosevelt and the French Report and relate this to the role of scientists in helping decision makers.	Science in Society: Looking to the Future Science in Society: Teacher's Guide
4.3 Describe the potential effects of microprocessors upon lifestyles of individuals.	Refer to the earlier unit on Facts. "The Impace of the Microprocessor on Society" or "The Robots Are Coming" can be used to introduce likely effects of microprocessors upon employment and the nature of jobs.	Science in Society: Looking to the Future The Robots are Coming

OBJECTIVE	NOTES TO TEACHERS	
5.0 Define quality of life and relate this to alternatives for resource use, individual activities, lifestyle or other factors affecting the future.	Read "A Life Style for Today and Tomorrow" and "Quality of Life."	Scientific American, September 1977 "The Role of Microelectronics in Instrumentation and Control" NOTE: Articles rapidly become out of date in this area. Science in Society: Looking to the Future

OPTION VIII: SPECIAL RELATIVITY

TIME: 15-20 HOURS

RATIONALE: Since this unit uses fairly complex ideas and mathematics, it should be provided only for highly motivated classes or as a source of enrichment for outstanding students. The unit might fit well after developing kinematics, dynamics and frames of reference. If taught as a Physics 300 option, these topics should be reviewed. Teachers also may wish to experiment with other modifications such as decreasing the number of concepts and related ideas which are developed or concentrating upon one aspect of the unit.

PRIMARY REFERENCES: 1. Sandery, Peter. FOSP HSII: Special Relativity. Victoria, Australia: Heinemann Educational Australia Pty Ltd., 1972. (This is a module.)

OR

2. Rogers, Eric M. Physics for the Inquiring Mind. Princeton University Press, 1964. (Teacher's reference.)

OR

3. Giancoli, Douglas C. Physics. Englewood Cliffs, NJ: Prentice-Hall Inc., 1980.

All of the above books cover special relativity in a complete fashion. Although Physics for the Inquiring Mind does not provide questions, the text does provide interesting approaches with diagrams which simplify complex concepts.

OBJECTIVE	NOTES TO TEACHERS
1.0 Frames of Reference	*FOSP HSII: Special Relativity* Unit 1 *Physics* 24.1, pages 618-621 *Physics for the Inquiring Mind* Pages 472-473
2.0 Galilean Transformation	*FOSP HSII: Special Relativity* Unit 1 *Physics* 24.12 *Physics for the Inquiring Mind* Page 474
3.0 Postulates of Special Relativity	*FOSP HSII: Special Relativity* Pages 14-17 *Physics* Pages 626-627

OBJECTIVE	NOTES TO TEACHERS
4.0 Michelson-Morley Experiment	FOSP HSII: Special Relativity Pages 16-17 Physics Pages 622-625 Physics for the Inquiring Mind Pages 478-480
5.0 Time Dilation (twin paradox)	FOSP HSII: Special Relativity Pages 18-24 and 49-50 Physics Pages 629-633
6.0 Length Contraction	FOSP HSII: Special Relativity Pages 24-27 Physics Pages 633-635 Physics for the Inquiring Mind Page 485

OBJECTIVE	NOTES TO TEACHERS
7.0 Mass Increase	FOSP HSII: Special Relativity Pages 30-32 Physics Page 636 Physics for the Inquiring Mind Pages 485-489
8.0 Relativistic Addition of Velocities	FOSP HSII: Special Relativity Pages 36-38 Physics Pages 639-640 Physics for the Inquiring Mind Pages 489-490
9.0 Lorentz Transformation	FOSP HSII: Special Relativity Pages 20-29 and 32 Physics Pages 642-644 Physics for the Inquiring Mind Pages 483-485

OBJECTIVE	NOTES TO TEACHERS
10.0 Simultaneity of Events	FOSP HSII: Special Relativity Pages 34-35 Physics for the Inquiring Mind Pages 492-495 Physics Pages 627-629 Each of the three books digresses into other areas. It seems that the ten above topics cover special relativity to as much depth (probably more) than one may wish to dare.

OPTION IX: RADIATION AND SOME OF ITS BIOLOGICAL EFFECTS TIME: 20 Hours

RATIONALE: The intent of this unit is to familiarize students with some of the common forms of nuclear radiation and to foster an awareness of the effects that radiation has on living matter.

The unit is best placed at the end of the 300 course and could stand alone. Another alternative may be to combine sections of this unit with the optional unit on "Historical Development of the Atomic Theory."

The unit will give only a superficial overview of this vast discipline; however, it contains sufficient information to give students an understanding of the hazards and benefits of nuclear radiation.

The fear of a nuclear holocaust and the fear of nuclear energy generation may be well founded, yet much of the information available in the media is misleading. Radiation levels are often reported but their meaning and effects on the ecosystem are rarely explained or understood.

This unit will give a brief explanation of the common types of radiation, their characteristics, the measurement techniques employed for their detection and their effects on biological matter.

A field trip to the Whiteshell Nuclear Research Establishment which deals specifically with radiation hazards is strongly recommended for the end of the unit.

Due to the nature of the topic, experimentation is not advised even though various kits are available. The content may be reinforced through readings and discussion. References to nuclear dangers appear almost daily in the media. These would form a good base for analysis and discussion.

A word of caution to the teacher: the allocated time is twenty hours but the first three or four of the nine objectives could easily consume the alloted time. Do not get bogged down in detail. A general overview will suffice. The last four or five objectives will generate the most interest and controversy.

It is not necessary that students memorize the radiation units and their equivalents. The main goal should be understanding. Reference tables can always be consulted when necessary.

PRIMARY REFERENCES:

1. Johnson, H.M. *Ionizing Radiation Properties and Detection*. Health and Safety Division and Whiteshell Nuclear Research Establishment. (Available from Curriculum Development and Implementation Branch, Department of Education.)

*2. Lindenfeld, P. *Radioactive Radiations and their Biological Effects*. Stony Brook, NY: American Association of Physics Teachers, 1984. (Mimeo.)

SUPPLEMENTARY REFERENCES:

*1. Laws, Priscilla W. *Ionizing Radiation in Health Care*. Stony Brook, NY: American Association of Physics Teachers. (Mimeo.) (This material could easily be used to extend this unit.)

2. Paul, Douglas et al. *Physics, A Human Endeavour: Unit 6, The New Physics*. Toronto: Holt, Rinehart and Winston of Canada Ltd., 1976.

3. Giancoli, Douglas C. *Physics*. Englewood Cliffs, NJ: Prentice-Hall Inc., 1980.

AUDIO-VISUAL:

1. "Perspectives on Energy." Atomic Energy of Canada Ltd. (A filmstrip series.) (A sample copy is available from the Manitoba Department of Education Library.)

OBJECTIVE	NOTES TO TEACHERS
The student should be able to:	
1.0 Define radiation. 1.1 Explain radiation as the emission of energy in wave or particle form.	Ionizing Radiation Properties and Detection 1.1, "Definition of Ionizing Radiation" 1.2, "Historical Development"
1.2 Identify the sources of natural radiation.	Radioactive Radiations and Their Biological Effects 1, "Introduction" 2, "Natural Background Radiation"
1.3 Identify and name the various areas of the electromagnetic spectrum that are considered harmful radiation, e.g., x-rays, γ rays.	
1.4 Describe alpha, beta and gamma radiation in terms of their respective properties.	
1.5 Distinguish between particle radiation (alpha and beta) and wave radiation (gamma and x-rays).	

OBJECTIVE	NOTES TO TEACHERS
2.0 Describe the quality and sources of ionizing radiation.	
2.1 Distinguish between radiation quality and source, e.g., electron radiation is a quality resulting from beta decay.	
2.2 In general terms, describe the operation of "man-made" sources and their products, e.g., cathode ray and x-ray tubes, particle accelerators.	Ionizing Radiation Properties and Detection 2.11, "Machine Sources" 2.12, "Nuclear Sources"
3.0 State the effects of ionizing radiation.	
3.1 Describe the ionizing effect of radiation on an atom.	Ionizing Radiation Properties and Detection 2.2, "The Effect of Ionizing Radiation" Radioactive Radiations and Their Biological Effects 2(c), "Measurement of Radiation Effects"
4.0 Define radioactive activity in terms of Curies and Becquerels.	

OBJECTIVE	NOTES TO TEACHERS	
4.1 Define radiation exposure and exposure rate.	This could become complex. The teacher should take care to proceed slowly with sufficient examples. An understanding of objectives 4.0 to 4.3 is crucial.	Ionizing Radiation Properties and Detection 3.1, "Radioactivity" 3.2, "Radiation and Exposure Rate" 3.3, "Radiation Dose and Dose Rate" 3.4, "Radiation Dose Equivalent and Dose Equivalent Rate" 3.5, "A Perspective of Dose Equivalents"
4.2 Define radiation dose and dose rate.		
4.3 Define dose equivalent and equivalent rate.		Radioactive Radiations and Their Biological Effects 2(d), "Ionization Exposure" 2(e), "Absorbed Energy" 2(f), "Biological Response"
5.0 Describe the use of the quality factor in assessing the biological effect of radiation.	Discuss the effects of different kinds of radiation and methods of protection.	Radioactive Radiations and Their Biological Effects 2(g), "Linear Energy Transfer" 2(h), "Background Dose Estimates"
5.1 Explain the bearing the quality factor has on the amount of energy absorbed by biological matter.	The dose equivalent is the prime factor in assessing biological damage. Dose Equivalent = Dose x Quality Factor	

OBJECTIVE	NOTES TO TEACHERS
	Solve sample problems from Radioactive Radiation and their Biological Effects NOTE: Problems on page 13 may pose difficulties. The instructor should attempt them first.
6.0 Describe, in general terms, the detection techniques employed.	
6.1 Describe the operation of a pulse counter, e.g., Geiger Mueller Tubes.	Ionizing Radiation Properties and Detection 4.1, "Pulse Counter" 4.2, "Pulse Integration"
6.2 Describe the operation of pulse integration detectors, i.e., photo badges worn by nuclear research personnel.	
7.0 Describe, in general terms, the biological effects of ionizing radiation.	Radioactive Radiations and Their Biological Effects 3(a), "The Discovery of Radioactivity and its Biological Effects" 3(b), "The Three Stages of Radiation Effects" 3(c), "Genetic Effects
7.1 Relate the history of discovery of ionizing radiation.	The history of Roentgen's and Curie's discoveries can be discussed.
7.2 Describe the three stages of radiation effects on biological matter.	The three stages are: . atomic disturbance and molecular disturbance; . the molecule and its surroundings;

OBJECTIVE	NOTES TO TEACHERS	
	. the cell's biological process is disturbed.	
7.3 Describe the genetic effects of radiation exposure: . chromosome damage . gene damage	A brief discussion of DNA in genes and chromosomes and the function of genes and chromosomes in the cells can be held.	
8.0 Describe other short- and long-term biological effects of radiation.		Radioactive Radiations and Their Biological Effects 3(d), "Acute Somatic Effects" 3(e), "Cancer" 3(f), "Estimate of Damage from Low Dose Rates"
8.1 Describe acute somatic effects.		
8.2 Describe the radiation therapy used in treating cancer.	A field trip to hospitals or medical guest speakers may be arranged.	
8.3 Describe the cancer-causing aspects of ionizing radiation.		
9.0 Critically discuss the social implications of the nuclear age.	The last objective could serve as the evaluative portion of the unit. A properly researched and documented paper on a relevant topic may provide the best summary.	Radioactive Radiations and Their Biological Effects 4, "Readings, Quotations and Bibliography"
9.1 Evaluate media presentations.		
9.2 Read and report on journal articles and research.		

appendices

APPENDIX A
ANNOTATED BIBLIOGRAPHY

CORE

1. Williams, John E. et al. Modern Physics. Toronto: Holt, Rinehart and Winston Publishers, 1984.

   This text adequately covers the "core" aspects of Physics 200 and 300 in depth except for some limitations on projectile motion and Kepler's laws. In addition, some options can be developed using this text. The topics often use a mathematical approach as well as technological applications; however, little information is provided on social impact. The text is generally metric (not SI) and some other units are used. Solutions to sample problems are presented and reading level varies depending upon vocabulary and need to express relationships in mathematical terms. A teacher's edition is available.

2. Haber-Schaim, Uri et al. PSSC Physics, fifth edition. Toronto: D.C. Heath and Company, 1981.

   This fifth edition of PSSC Physics begins with mechanics and has removed most of the information about heat. A strong emphasis on optics and quantum mechanics is retained. The text adequately covers the Physics 200 course but has some limitations in the area of electricity in Physics 300. The content and level is suitable for above-average students and makes a demand upon students' abilities to follow rigorous algebraic arguments. Some technological material is available in regard to the social impact of science. The text is SI except for the use of an elementary change rather than the coulomb. This tends to affect some of the constants used. Assignments vary in their levels. A teacher's edition is available.

3. Spronk, Cornelis and Brian Martin. Physic-Al: An Activity Approach. Edmonton: J.M. LeBel Enterprises Ltd., 1984.

   This text adequately covers the "core" aspects of Physics 200 only; however, limitations exist in the emphasis upon gravity and Kepler's laws. The mathematical development and directed laboratory activities are integrated into the content. Generally, inexpensive equipment is required for the laboratory activities. Sample problems and a limited number of additional problems for student use are provided. The material is easily read by most physics students and is provided in black and white. Diagrams and graphs are integrated into the text.

4. Williams, John E. et al. Exercises and Experiments in Physics: Modern Physics or Modern Physics: Laboratory Experiments in Physics. Toronto: Holt, Rinehart and Winston Publishers, 1984.

   This laboratory manual provides experiments which will adequately relate to the course. Some laboratory activities are low-level and others require a higher level of algebra. Instructions for experiments are clear and often of the cookbook variety. Most experiments are of standard format and do not require unusual equipment. A teacher's guide is available.

5. Haber-Schaim, Uri et al. PSSC Physics Laboratory Guide, fifth edition. Toronto: D.C. Heath and Company, 1981.

   This laboratory manual provides experiments which will adequately relate to all areas except for some of the electricity. Experiments often require students to do some independent thinking. Instructions are clear and partial; however, they are in the narrative form. A teacher's resource book is available.

OPTIONS

1. Lewis, John L. (project director) Science in Society: Teacher's Guide. London: Heinemann Educational Books Ltd., 1981. (Canadian representative: Richmond Hill, ON: Irwin Publishing Inc.)

   This guide, either alone for some topics or in conjunction with student materials, supports the options Facts I, Facts II, Energy, and Futures: Science, Technology and Society. The guide also examines topics such as Food and Agriculture, Population and others which could be used in other courses. A number of alternative approaches and specific suggestions are made for developing a topic. Although the guide has some limitations in its use because of its many references to audio-visual and other texts from British sources, these texts often can be found in North America and specific examples often can be Canadianized. Many units are also developed from a worldwide perspective. Suggestions for the use of the students' modules are present within the guide.

   ----------. Science in Society: Nature of Science (Book J).

   This student module contains a series of articles on the nature of the scientific method, on how science develops, on creativity and on the limitations of science and its relationship to society. Partial class sets would be satisfactory.

   ----------. Science in Society: Science and Social Development (Book K).

   This student module contains a series of articles on the development of science, technology and society in earlier times, Galileo, Bacon and Newton, science and the industrial revolution. Partial class sets would be satisfactory.

   ----------. Science in Society: Energy (Book F).

   This student module contains articles on electrical generation and transmission, nuclear reactions and power, alternative sources of energy, and risks of energy provision. Partial class sets of materials would be satisfactory.

----------. Science in Society: Looking to the Future (Book L).

This student module contains articles on the general relationship among technologies, resources and development, appropriate technologies, the potential impact of the microprocessor, lifestyle, and the relationship between science-technology and quality of life. Partial class sets of materials would be satisfactory.

----------. Science in Society: Power Station Project and Science in Society: Alternative Energy Project.

These are simulations which attempt to have students make decisions using certain variables or criteria. Each package includes a teacher's guide and student materials. These projects supplement or extend the energy units in the Physics 300 course.

2. Solomon, Joan. Science in a Social Context: How Can We Be Sure? Oxford: Basil Blackwell Publishers Ltd., 1983.

This student module examines induction and deduction, the birth of scientific theories, and the nature of scientific disagreement in less depth or rigour than the Lewis materials do. Although a teacher's guide is available, it is not necessary. Partial class sets of student materials would be satisfactory.

----------. Science in a Social Context: Technology, Invention and Industry.

This student module examines the ingredients for invention and provides case studies in plastics and microelectronics. It provides an excellent background for examining the relationship between science and technology. Although a teacher's guide is available, it is not necessary. Partial class sets of student materials would be satisfactory.

3. Jenkins, Frank. ALCHEM: Nuclear Chemistry and Solar Energy: Solar Education for the 80's. Edmonton: J.M. LeBel Enterprises Limited, 1980.

Both modules develop the basic concepts or principles relative to the specific source of energy which is considered and then apply the principles. The materials use Canadian data and examples as needed, e.g., the CANDU nuclear reactor. Some advantages and disadvantages are explored. The materials direct students from content through activities and problems. Teacher's guides are available.

4. Paul, Douglas et al. Physics, A Human Endeavour: Unit 2, Motion in the Heavens and Physics, A Human Endeavour: Unit 4, The Nature of Light and Sound and Physics, A Human Endeavour: Unit 6, The New Physics. Toronto: Holt, Rinehart and Winston of Canada, Limited, 1976.

These modules combine science content with historical and technological-social relationships. The reading level is satisfactory for the average physics student. Questions are generally integrated into the content with additional problems at the end of the chapters. A handbook, which suggests experiments and activities, is a part of each module. Generally simple equipment is used; however, teachers should examine equipment needs because the kind required will vary. No teacher's guide is available.

5. Marion, Jerry B. and Marvin L. Rousch. Energy in Perspective, second edition. Toronto: Academic Press, 1982.

   This is a soft-cover text which adequately covers the energy options (VIa and VIb) and also supports the unit on biological effects of radiation. Topics developed include work, power and energy; energy consumption, sources of energy, nuclear power, the effects of nuclear radiation, energy and the environment, and energy in the future. Although U.S.-oriented, the book provides a good overview of many energy sources and technologies. It can be used as a teacher resource or in partial class sets for students.

6. Phillips, Hugh (program director). SEEDS: Energy Technologies and SEEDS: Energy in the Future. Toronto: Science Research Associates (Canada) Ltd., 1983.

   These are Canadian modules which examine a variety of alternative energy sources and technologies. The nature of energy sources and technologies, environmental effects, the effect of energy conservation, and future possibilities are emphasized in the modules to different degrees. One or both modules can be used to support different aspects of the energy option(s) in Physics 300. Both content and process are present within the design. Teachers' guides are available.

7. Lindenfeld, Peter. Radioactive Radiations and their Biological Effects. Stony Brook, NY: American Association of Physics Teachers, 1984. (Mimeo)

   This module includes content on background radiation, and readings (for class discussion) dealing with use of radiation, fuel reprocessing, waste disposal and other related areas. Problem sets are present in the material. The material may be used as teacher reference or student materials.

8. Silverman, Wayne. Earthquake Prediction. Stony Brook, NY: American Association of Physics Teachers. (Mimeo)

   This module includes content on the characteristics of earthquake waves and their predictive uses, alternate ways of predicting the possibility of earthquakes, and earthquake theories. Problem sets are present in the material. The material may be used as a teacher reference or partial class sets.

9. Henriksen, Peter and Paul Payerle. Sunburn and Sunscreens. Stony Brook, NY: American Association of Physics Teachers, 1980. (Mimeo)

This module includes content on electromagnetic radiation, the role of the atmosphere as a filter and skin damage caused by radiation and sunscreens. Some laboratory projects are suggested; however, equipment needs and safety factors may be quite limiting. Some problem sets and discussion questions are provided. The material may be used as a teacher reference or partial class sets.

APPENDIX B
SCIENCE PROCESS SKILLS

An important goal of science instruction in Manitoba schools is to encourage students to become increasingly active investigators of science. Instruction in the processes of science begins in the elementary grades and continues through high school. Following is a list, with definitions, of the process skills that the program aims to develop.

Observing - Competence in using the senses and mechanisms for extending these senses in the collection of data from physical phenomena.

Classifying - Competence in grouping articles, objects and ideas on the basis of some observable physical and chemical attributes.

Quantifying - Competence in using numbers and in measuring length, weight, area, volume, concentrations and rate of change in physical phenomena.

Formulating Hypotheses - Competence in making an hypothesis (if/then statement) regarding the causes of a phenomenon or the relationship between two variables.

Making Operational Definitions - Competence in stating the operation to be performed and the observations to be made in applying a definition to an experiment.

Controlling and Manipulating Variables - Competence in making decisions concerning the control and manipulation of objects or conditions in an experiment, and in arranging conditions.

Interpreting Data - Competence in getting the most out of data without oversimplifying, in drawing conclusions supported by the data, and in considering alternative explanations on the basis of supplied or observed data.

Formulating Models - Competence in building both physical and mental models to account for phenomena.

Communicating - Competence in describing an experiment so that an individual who has not seen it can carry it out.

Inferring - Competence in drawing more than one inference or conclusion from a set of data, in demonstrating that an inference can be tested by applying known tests to the properties of objects, and in distinguishing between observations and inferences.

Predicting - Competence in conducting experiments to test predictions of relationships between two measurable quantities.

Experimenting - Competence in planning, conducting and communicating an experiment in which the problem is clarified, hypotheses are stated, observations are made, and data is interpreted. This process depends upon the use of all the other processes.

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